METALLURGIA

The British Journal of Metals

(INCORPORATING THE METALLURGICAL ENGINEER.)

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PRINCIPAL CONTENTS IN THIS ISSUE:

	Page
Use of Electricity in Industrial Heat-Treatment. By A. Glynne Lobley, M.Sc.	61–64
The interest in the use of electric furnaces for heat-treatment continues to grow rapidly, and there are to-day many important examples of industrial electric heat-treatment in Great Britain. The development of the electric resistance furnace has been very rapid, and its applications have spread over a wide field, and for this reason the author gives an account of what has been done in this field.	
Retrospect and Prospect	65
Rod Mills	66
Details of a notable design.	
Institute of Metals: Annual Meeting	66
Steel-making Alloys. By W. F. Rowden	67–72
Certain elements have a considerable influence on steel; in application their primary object may be as purifying agents, or, when alloyed, to confer on the steel certain desirable qualities. Because of their usefulness in steel manufacture, these elements have an importance that is out of proportion to their volume. The functions of a number of these elements are discussed, and the manufacture of a selected alloy steel described in this article.	
Development of the Ferrous Alloys Industry in the Soviet Union	72
Principles of Heat-Treatment. By a Special Correspondent	73–74
Rapid progress has been made during recent years in furnace design and construction, but unless the fundamental principles associated with the apparently simple heating and cooling of metals and alloys are understood, the improved mechanisms now available will not give the high efficiency possible. In this article the author reviews the principles of heat-treatment in the light of recent developments.	
Non-Ferrous Metal Production	75–78
The importance of the mineral industries to the Dominions is becoming increasingly manifest; it has kept the wheels of industry turning during a period of extreme difficulty, and assisted the sadly depleted export trade of these countries. Developments in Empire production of base metals are discussed.	
Book of A.S.T.M. Tentative Standards	78
Forthcoming Meetings	78
Aluminium in the Chemical Industry	79–80
The advantages of aluminium as a structural material for the chemical industry result from its high resistance to corrosion by many corrosive media, the colourless, non-toxic character of the corrosion products, and their inability to catalyse oxidation or other changes, and the combination of lightness, strength, and high thermal and electrical conductivity.	
Sintering for the Blast-furnace	80
Two notable plants at Dagenham and Corby are discussed.	
Recent Developments in Tools and Equipment	81–84
A new Light Self-Indicating Universal Testing machine. A New Bale-out Furnace for Aluminium. Indicating and Recording Instruments.	
The Engineer's Training for Industry	84
Some Recent Inventions	85
Metallurgical Furnaces. Coke Oven Doors. Refining Copper.	
New British Chemical Standards	86
Business Notes and News	86–87
Metal Prices	88

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THE BRITISH JOURNAL OF METALS.

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JANUARY, 1935. VOL. XI., No. 63.

Use of Electric Furnaces in Industrial Heat-Treatment

By A. GLYNNE LOBLEY, M.Sc.

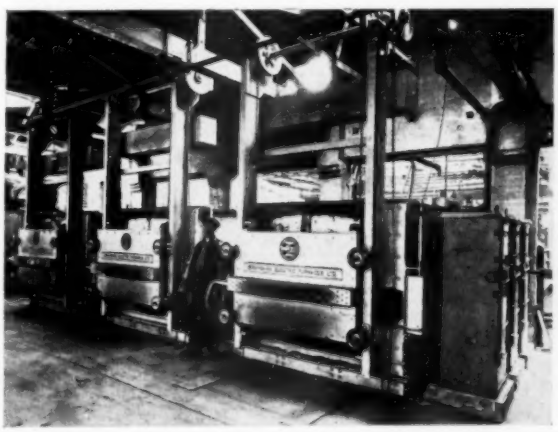
The interest taken in the use of electric furnaces for heat-treatment continues to grow rapidly, and there are to-day many important examples of industrial electric heat-treatment in Great Britain. The development of the electric resistance furnace has been very rapid, and its applications have spread over a wide field, and for this reason it is thought that some account of what has been done may be of interest to many engaged in industries which make use of heat-treatment.

IT will be realised that there are many aspects of the subject, any one of which would provide ample material for an article. Here, however, it is proposed to view the subject in a general manner, touching briefly on its various aspects, and describing some of the many applications.

It is well known that the electric resistance furnace was made available to industry by the invention of the nickel-chromium alloys. Previous to this the only metal available was platinum, which was too expensive to be used in anything larger than small laboratory muffles or tubes. In designing the larger units, however, a radical change in the arrangement of the heating elements became necessary. In the case of small muffles it was, and is, customary to wind the resistance wire on the outside of a refractory muffle. This method would obviously be difficult to use in a large furnace, but in any case is ruled out for another reason. In the laboratory muffle the heat requirements are small, so that once the furnace is hot, very little heat is passing from the elements through the refractory. On the other hand, with the large industrial furnace the conditions are very different. Heat must be passed from the elements to the charge almost continuously, and often at a high rate. The intervention of a refractory wall under these conditions would not only create a large temperature gradient, but would seriously interfere with the accuracy of the temperature control. It is therefore necessary to mount the heating elements on the inside of the chamber, so that heat can be radiated directly to the charge. At high temperatures heat can be radiated rapidly with comparatively small differences of temperature, so that practically all methods of arranging the resistors or heating elements have aimed at this idea of free radiation. There are two main exceptions to this, one being the case of low-temperature furnaces where the heat is transmitted by forced-air circulation, and the other where an embedded element is used. This latter case is restricted to comparatively small furnaces where the heat required per unit of wall surface is low, and, moreover, the refractory used is one having an especially good heat conductivity.

Arranging Heating Elements.

Much thought has been given to the methods of supporting and arranging heating elements. Various forms of elements are used—wire, rod, ribbon, heavy strip, and cast section, and for each form there are several methods of support. Briefly, the different methods are: wire, in the form of helices, supported on ledges, in grooves, or even (in certain cases where high heat inputs are not required), in tunnels or embedded in a refractory, having a high electrical resistance combined with a good heat conductivity. Rod is used in the form of straight lengths or hair-pins, supported at intervals along its whole length by refractory or in sinuous or zig-zag form supported on hooks or refractory. Strip or ribbon may be in the form of helices, but is almost invariably mounted in the form of sinuous or zig-zag elements, edge-on to the wall, supported on refractory or metal hooks. Strip is also used flat on to the wall, given self-supporting properties by being fluted or shaped like a cycle rim. Such elements are usually in sinuous form supported at the ends, but they are somewhat difficult to make, and require careful design, properly providing for free radiation of heat and the limiations of the moulder and caster. Most of these methods may give excellent results when handled by a competent designer using suitable material, provided the method is applied to a process or type of furnace for which it is suitable. The geographical distribution of these methods is somewhat interesting. Speaking generally, the Continental builders have usually used the wire-spiral method, and American builders strip, ribbon and cast elements. British builders have used all these methods, but to-day practically only use, in the case of large furnaces, strip, rod and cast elements. The difference between Continental and American methods is becoming much less marked.



Three 110-k.w. furnaces for carburising, sliding-type doors.

Contrary to the popular idea, the heating element of an electric furnace has normally a very long life. It does not fail by oxidation, but by chemical attack of injurious

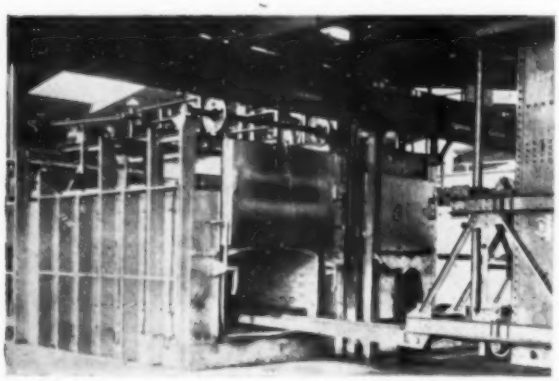
175-k.w. furnace for annealing brass—14′ 0″ long × 3′ 9″ wide inside.

gases emitted by the material being treated, or by interaction with the supporting refractory, this also usually only occurring when injurious gases are present. Normally, however, as already stated, heating elements have a very long life, the cost of renewal being by no means a heavy maintenance cost. There are many cases of furnaces which have been in continuous use for five to eight years with the same heating elements which, moreover, are apparently as good to-day as ever.

Advantages of Electrical Heating.

The earliest furnaces were naturally of the simple batch type, but mechanical handling of the charge and many other improvements and adaptations have been added, until to-day the electrical furnace exists in very many different types and forms. At this point one may well pause to ask what are the reasons which have led to the present position of rapidly-growing importance. Especially may one ask this, in view of the prevalent ideas that electrical heating is expensive. There are a large number of advantages which attend the use of the electric furnace, and these are nearly all derived from two inherent properties, namely, ease of control and flexibility. Ease of control comes from the fact that the whole of the electrical energy put into a furnace is converted into heat, so that control of the electrical energy means control of the heat, and it is well known that electrical energy can be readily, instantly and accurately controlled. Further, since the heat is produced without combustion, there are no requirements for air ducts, combustion chambers or flues to interfere with the disposition of the heating elements or the general design of the heating chamber. Thus the heat distribution may be arranged to give a uniformity of temperature throughout the chamber which is unattainable by other means, and it will be seen that this flexibility

300-k.w. furnace for annealing heavy brass strip; takes 4-ton loads. Fitted with forced-air circulation and recuperative chambers; charging machine and electrically-operated doors.



and adaptability enable electric heating to be combined with all types of mechanism for manipulating the charge. Further, special furnace atmospheres may be used irrespective of any question of efficiency of combustion for heating purposes, so enabling bright annealing or clean hardening results to be obtained superior to those obtained when using other types of furnaces. All these points lead to a high quality of product with improved working conditions, eliminating the human factor to a considerable degree. In short, in the industrial electric furnace, the results of the laboratory can be reproduced with certainty and exactitude.

The use of the electric furnace has grown, and can only grow through economic reasons. In many cases there is a saving in the direct heating cost, but it is not necessary for the direct operating cost to be cheaper, so long as the advantages produce a saving directly or indirectly, or enable a higher price to be obtained for the product. The savings may be due to the elimination of rejects, the more economical working of subsequent processes, or by the consistent high quality of the product allowing the whole machinery of production to proceed more smoothly. It is however, not always easy to assess the exact influence of these advantages on works cost, and it is a fact that when an electric furnace is installed some unlooked-for advantages are nearly always found in addition to those expected. The fact that so many of the furnaces being installed to-day are being put into factories where there are already electric furnaces, shows that the real nature of these advantages is by no means exaggerated.

Heating Costs.

The idea that electric heat is expensive has arisen through comparisons being made between the cost of heat purchased as electrical energy and one of the fuels. This comparison, however, is an erroneous one, as it does not take into account the difference between the accessibility of the energy in various forms of fuel. Owing to the fact that there are no flues to waste heat, and that electrical energy can be converted into heat exactly at the point where it is required, most of the heat may be used usefully. In other words, the efficiency of the electric furnace is very high—many times higher than that of fuel furnaces. If, instead of comparing the cost per gross therm, one compares the cost of the heat which can be used, then there is much less difference between the cost of heat obtained in the various ways. It is not possible to make a definite table of costs per net therm, as it were, as the relative efficiencies of gas and fuel furnaces vary considerably according to the nature of the process. Owing to the absence of flues and the effect of really efficient insulation, the efficiency of the electric furnace is at its highest in proportion to other types when maintaining a constant temperature as required in many soaking operations. The direct heating cost, then, is most favourable to the electric furnace when the process involves a lengthy soaking period, as for example in carburising, nitriding, and the heat-treatment of aluminium alloys.

Lest this should be misunderstood, let it be added that many of the most successful electric furnace installations apparently operate under the opposite of these conditions, such as annealing or reheating operations in continuous or mass-production factories. Many reheating or annealing operations deal with material of such shape or nature that only comparatively small loads can be put in the furnace, and this again has the same effect on costs as a heavy load which has to be maintained at one temperature for a considerable time. Whilst considering direct heating costs, it should be remembered that not only do many electric supply authorities allow an especially cheap rate for electric furnaces (because of the favourable type of load), but the resistance furnace load so improves the load factor and the power factor of the total supply to the factory that the average rate paid for the non-furnace load is also reduced.

Types of Furnaces.

In general, most heat-treatment processes may be divided into batch and continuous methods. The batch method with the simple box-type of furnace was naturally developed first, and will always be popular owing to its ready adaptability to products varying widely in size, quantity and even type of treatment. Moreover, box-type furnaces have been improved in many details of construction, and the handling of the charge facilitated. Where there is a regular output of the same material, the continuous furnace offers many advantages. With this type, not only is the temperature controlled, but also the time factor, and the resulting consistency of treatment is obviously beneficial. Incidentally, the electrical load factor of this type is also superior to that of the batch-type furnace.

A box-type furnace may have a plain, flat hearth for hand-loading, or a slotted hearth for use with a charging machine. The former is usual with small furnaces, and the latter with larger units. The slotted hearth furnace with an electrically-operated charging machine is very commonly adopted for carburising and the annealing of metals in the form of sheets or strip and wire. With these furnaces the heating elements are usually mounted in the roof and the side walls and under the hearth, and in many cases on the inner surface of the door also. It is not always necessary or advisable to have the heat applied in all these positions, and it will depend on the type of material treated and whether artificial circulation of the air is adopted (referred to later). Roof and hearth heat are the most important, and are practically always retained in large furnaces, whilst side heat is usually the least important. It is difficult to generalise on this matter, as different purposes demand different arrangements.

Temperature Control.

Automatic temperature control is universally adopted with all but the very smallest furnaces. Special controlling pyrometers are used in conjunction with magnetic contactor switches. These instruments, which may be of the millivoltmeter deflectional type or the potentiometric type, may be set to control at any desired temperature within their range. On the furnace temperature reaching the set point the instrument operates the relay which breaks the controlling circuit of the contactor. This then opens, and the power is cut off the furnace. In a short time the temperature falls again, and the process is reversed, restoring power to the furnace. In this way the temperature is constantly fluctuating slightly around the control point. The amount of this fluctuation, whilst usually within plus or minus 5° C., varies considerably according to many factors, such as: the rating of the furnace, heat ballast of the furnace, weight of charge in the furnace, thickness of the thermocouple and its sheath, etc. When especially required, the fluctuation may be cut to a very small figure by the use of a light thermocouple carefully placed, or by adjusting the rating of the furnace so that the power is not largely in excess of that immediately required. This may be done by means of a tapped transformer, an induction regulator, or by a special instrument. In large furnaces it is very usual to divide the heating elements into several circuits, each controlled separately. This is known as zoning. It is adopted to ensure uniform temperature even when the furnace is unequally charged, and also in continuous furnaces to cope with the varying rate of heat absorption as the temperature of the charge rises.

Automatic temperature control, although adopted first with electric furnaces, is now commonly used in fuel furnaces, and such furnaces then show an equally accurate control, though not such a simple one, so far as temperature at the point where the thermocouple is placed is concerned. It is, however, equally important that the temperature shown by the thermocouple should be the temperature throughout the furnace or zone, and this much more

330-k.w. car-type furnace for heat-treatment of forgings, etc. 33′ 0″ long × 3′ 0″ wide inside.

usually obtains with the electric furnace than with any other type.

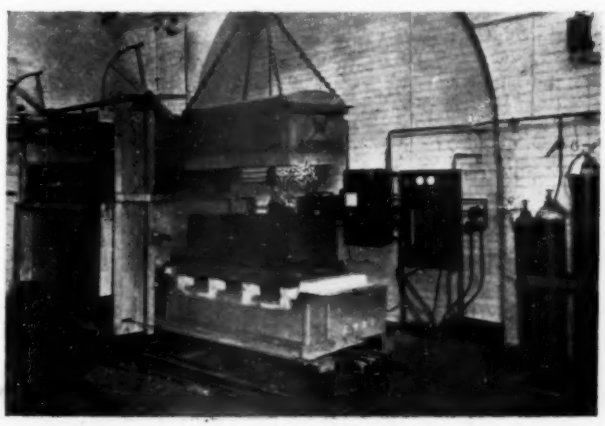
Batch-Type Furnaces.

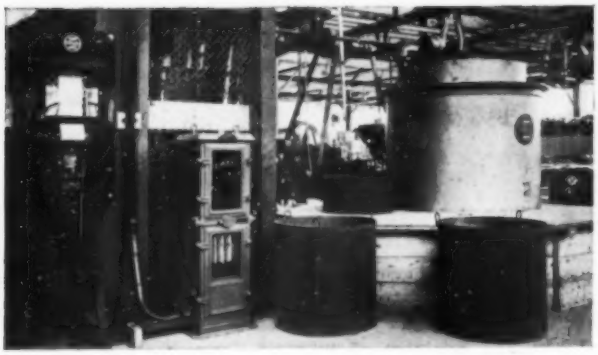
Practically all types of heat-treatment work may be carried out in box-type furnaces. Examples are illustrated of their use in connection with the carburising of steel, and the annealing of various metals. The electrical energy consumption in carburising is approximately 1 k.w.h. per 5 to 6½ lb. of gross load, according to the size of furnace and the depth of case required. The annealing of brass in this type of furnace ranges from about 85 k.w.h. per ton, according to the type of load and size of furnace, and whether operated continuously or only during the day. Obviously, in all cases, much greater economy is obtained in continuous operations.

In comparing the running costs with those of fuel furnaces, it should be remembered that the power required to *maintain* the temperature in an electric furnace is small—of the order of one-tenth of the maximum furnace rating, so that during periods when the load is light or the furnace is empty, the power consumption is reduced much more with the electric furnace than with other types. For this reason, figures taken over a long period are always more in favour of the electric furnace than those obtained from a short test.

Other methods for facilitating the charging and discharging of the furnace are used in certain cases; thus the hearth of a box-type furnace may be fitted with loose rollers, so that the charge can be rolled in and out on trays or in boxes. Where very heavy masses have to be treated, as in the case of large steel forgings, rolls, etc., the whole hearth may be made removable. This type of furnace is known as the car type, or bogie hearth furnace; the hearth being mounted on wheels, so that it can be withdrawn for

Nitriding furnace showing special duplex method.





Forced-air circulation furnace for annealing brass parts.

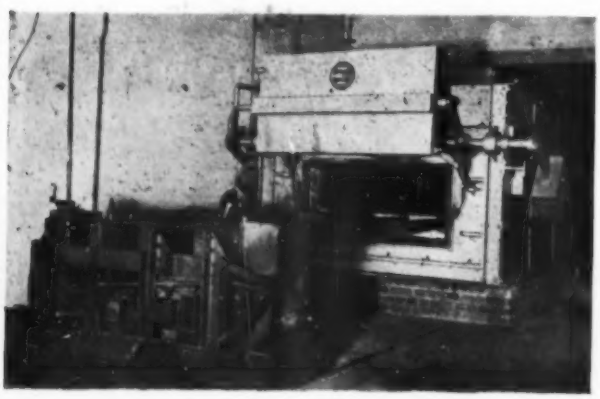
the purpose of loading and unloading. When in position a sand seal prevents undue loss of heat by air currents.

Before passing on to continuous furnaces and the automatic manipulation of the charge, it would be as well to review some of the special modifications which have been made to the batch-type furnace to make it more efficient for certain purposes. This is especially the case with low-temperature treatment where important advances have been made. The number of processes requiring low-temperature treatment has increased, and more use is being made of them. It is usually the case that accuracy of temperature control and uniformity of temperature are even more important in this domain than in the case of higher temperatures, and for these reasons the electric furnace is naturally preferred. It has therefore been necessary to devise electric furnaces in which these properties can be best made use of at low temperatures.

Forced-Air Circulation.

At the higher temperatures radiation is the most important factor in heat transference. Under these conditions the interplay of radiation in a well-designed furnace aids the uniformity of distribution of heat, and heat transference takes place rapidly. Since, however, radiation follows a law based on the fourth power of the absolute temperature, the importance of this transfer falls off very rapidly as the temperature is reduced, until it is no longer the principal factor. Whilst at temperatures of about 900° C. over 90% of heat transfer is by radiation; at the lower temperatures used for tempering, and many other operations, radiation becomes less important than convection. Unlike radiation, however, convection in itself does not necessarily lead to uniformity. It may cause stratification where the upper parts of the furnace chamber are at a higher temperature than the lower. In the normal way, then, in convection the heat is transferred by air currents, the existence of which is brought about by the effect of gravitation on air of different densities. More rapid heat transfer can be effected by means of artificial air currents. This fact has long been made use of, fans having been employed in certain small furnaces to agitate or circulate the air. More recently, however, attention has been devoted to increasing the efficiency of such furnaces, and enlarging their scope.

180-*k.w. carburising furnace with electrically-operated charging machine.*



The rapidity of the air currents is obviously definitely connected with the rate of heat transfer; the temperature gradient between the source of heat and the body to be heated thus: weight of air per unit time × temperature difference × K = heat transferred per unit time.

For a given rate of heat transfer, then, the temperature gradient is inversely proportional to the difference of temperature between the heating elements and the charge, assuming that there is no heat transfer by radiation or direct conduction. Even more important than this temperature gradient is the temperature gradient through the charge, along the path of the air currents, for as this is passing heat to the charge so must its temperature be lowered. This temperature gradient is, however, affected by the velocity of the air in precisely the same way. It is obvious that if rapid heating, together with small temperature gradients, is desired, rapid air velocities are necessary. In the earliest attempts to overcome this difficulty the expedient of reversing the fan, and therefore the air currents, was used with success. Recent improvements, however, have made use of special high-efficiency fans, such as the centrifugal fan, which are not reversible. However, the vastly increased air velocity now obtained make it unnecessary to reverse the air currents. The higher air velocity obtained with the centrifugal fans not only reduces the temperature gradient, but produces turbulence or secondary eddy currents which assist the air to penetrate thoroughly into all parts of the charge. These high air velocities not only allow rapid heating with small temperature gradients, but remove the stagnant air from the surface of the material to be treated, thus establishing more intimate contact with the heated air, further assisting rapid heat transfer.

Forced-air circulation furnaces of this type are usually in the form of vertical pit furnaces, and are standardised for operation at temperatures up to 650° C. In all these furnaces a shield prevents direct radiation from the elements to the charge, since such radiation would interfere with the uniformity of temperature. In certain cases, however, where the process is carried out at the upper end of this temperature range, where radiation is becoming useful, then agitating fans are used in addition to the direct radiation. This is commonly the case with large horizontal furnaces for the annealing of brass and similar metals. In these centrifugal fans are placed in the roof of the furnace. The result is that the rate of heating is considerably increased and a high degree of uniformity obtained without the necessity of so much resort to zoning. Moreover, the use of these fans gives greater freedom in the placing of the heating elements—side elements not being required. Although this second fan method is used in most of the brass furnaces built to-day, the large 300-k.w. furnace illustrated employs a directed air flow with the fan external to the chamber. Whilst the rate of heating is substantially increased with the use of fans at the annealing temperature of brass, increased oxidation also takes place.

Charge Progress Recorder.

An interesting method of showing when the charge is completely heated is by means of what is known as the charge progress recorder. This is a recording instrument connected to two thermocouples; one being placed at the top, in the vertical type of furnace (where the air leaves the elements), and the other where the air leaves the charge. The instrument controls the temperature by the upper thermocouple only. So long as the charge is absorbing heat there will be a difference between the temperature of the two thermocouples, and this is readily seen on the chart. When the two curves (one red, one black) coincide then the

(*Continued on page* 86.)

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RETROSPECT AND PROSPECT

The outlook for trade and industry is better than for some time past.

THE trade returns for 1934 are satisfactory in view of the difficult world conditions that continue to exist. They show that the recovery in British trade, which began about the middle of 1932, has gathered momentum, although much progress must be made before the amount of trade approaches what has been referred to as normal. Imports are up, as compared with last year, by £57,314,704, and exports by £28,198,492. Re-exports also show an increase of over £2,000,000. A gratifying feature of the imports is that slightly more than half the increase during the years was contributed by raw materials. Another important fact indicated by the returns is that the increase in exports was almost wholly accounted for by manufactured goods, the exports of which rose by £23,200,000.

Although there has been substantial improvement in British exports during 1934, the adverse balance of payments, including invisible exports, against the United Kingdom seems larger than in 1933. Imports of merchandise in 1934 exceeded exports by £294,598,000, whereas the corresponding deficit for 1933 was £263,076,000. In 1933 the invisible exports, represented by income from interest on overseas investments, shipping earnings, and other services, was £260,000,000, leaving a small net adverse balance of about £3,000,000. Any adverse balance on 1934 trading can only be conjecture, as the official estimate of the invisible items, for which credit can be taken, is not yet available, but it is suggested the total value of these items has increased.

Generally, the returns show that the year has been one of definite advance; that, in addition to improvement in the home trade, there has been an agreeable expansion in overseas trade, though in some directions recovery has been slower than a year ago. This improvement has been effected despite the increase of international difficulties. Actually, during the year, trade restrictions have increased, more exchange impediments and moratoria have arisen, and the resort to barter by some countries has interfered with the established channels of trade.

The recovery which has taken place really commenced in November, 1931, when the Abnormal Importations (Customs Duties) Act was introduced, to be replaced early in 1932 by the Import Duties Act, which laid the foundations of the future British tariff structure. Later, during the same year, at the Ottawa Conference, the broad principles of the future Imperial policy were discussed, and the basis of the mutual relations between the United Kingdom and the Dominions defined and development agreed upon. The new sterling system had an important influence at this time. Proceeding on well-ordered lines, and with a desire to effect sound trading facilities, a number of commercial agreements were negotiated with Denmark, Norway, Sweden, Finland, Latvia, Lithuania, Estonia, the Argentine, and Iceland, while trading arrangements were also made with France, Germany, and Russia.

It would be impossible to define the extent that each development has contributed in the recovery, but some measure of the effects of the Ottawa agreements and the bilateral commercial agreements with non-Empire countries is provided by figures recently published by the Board of Trade. These show that the share of the Empire, both of imports and exports, has increased. In 1932, for instance, the Empire provided 35·2% of the total imports into the United Kingdom, and took 45·5% of her exports. In 1934 the proportions were 37·4% and 46·1%, respectively. This improvement cannot be wholly due to the Ottawa agreements, because it was only towards the end of 1933 that they became effective, but since that time movement has been progressive, and the future trend is hopeful. It is true that these agreements are shortly due for reconsideration, and no doubt the question of competition with Dominion secondary production in their home markets will arise. Some of the Dominions ask for unlimited entry for their primary products into the United Kingdom, but do not seem disposed to reciprocate by the return of manufactured goods.

The recovery in foreign trade is considerable. While the imports remain about the same as in 1932, the exports are appreciably greater, in which practically all the primary industries have participated. Much of this increase is due to improved trade with the Argentine, Scandinavia, and the Baltic States. Under present conditions the bilateral bargaining, which has contributed to this improvement, seems to be the only way to break down economic nationalism, and a continuance of this policy may be expected, because, despite improvement in the home market, the only way in which Great Britain can proceed to develop is by a continual increase of her overseas trade.

The Import Duties Act has had one important influence on industry; it has enabled much reconstruction to be effected in the coal, iron and steel, and cotton industries, and there is solid reason for believing that the steps so far taken are giving profitable results. In the coal and iron and steel industries, for instance, there has been a considerable increase in employment. Not only is much reconstruction completed and in progress, but new works and extensions are being carried out. In the near future, for instance, two large steel-making plants will commence—the new works in the Corby district of Stewarts and Lloyds, which will have a capacity of 240,000 tons of Bessemer steel ingots per annum, and the new works of Guest, Keen and Nettlefolds, at Cardiff, which will have a capacity of 300,000 tons steel billets and bars per annum.

With continued development of the various means of production the ability of the industries to compete in the world's markets will improve. But the great problem is to break down the policy of economic nationalism which prevails. This, in essence, is a policy of isolation which is narrow and incomplete, and can never replace the natural exchange of goods and services. If this difficulty could be overcome we believe a great step forward would become possible, because there is a demand for goods which cannot be adequately met under present conditions.

Bearing in mind the great difficulties Great Britain has so far surmounted, the fact that she is in the van of world recovery is a tribute to the fundamental strength of her national position and the determination of her people. Certainly, at the present moment, she is as well placed, taking the whole economic situation into consideration, as any country in the world. The favourable position is due, in no small measure, to the soundness of the broad lines of the policy which the Government has followed, and the outlook is definitely better than for some time past.

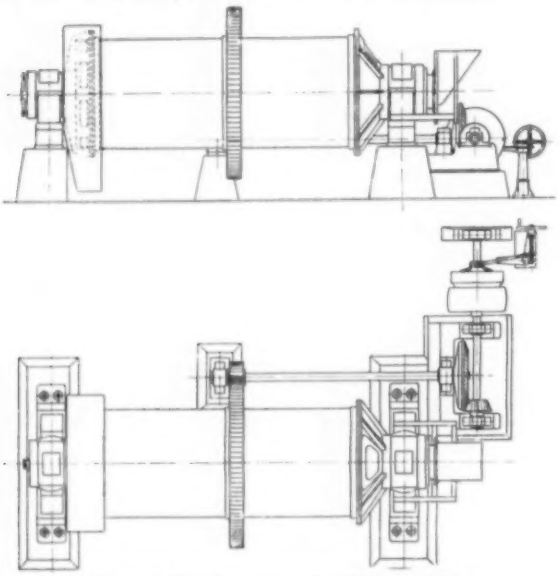
ROD MILLS.

Details of a Notable Design.

FOR many grinding applications, including the treatment of damp products such as ores, rock, and wet coal, the rod mill, when designed and constructed on right lines, is a highly efficient machine. Some of the advantages include uniform size of each particle (that is, with little oversize or undersize), low power consumption, and minimum dust formation.

In this connection considerable interest attaches to the latest designs of rod mill supplied by Sutcliffe, Speakman and Co., Ltd., of Leigh (Lancs.). A mill of this type, for example, is included in the new sand-lime brick plant recently completed at Holmethorpe, Redhill (Surrey), having a capacity of 600,000 bricks per week, to which reference has already been made in these columns. The matter is also highly interesting because bricks can be made from blast-furnace slag by this process, and a number of plants are operating at iron and steel works.

Slaking the lime in this connection is best carried out on the silo principle, as also used at Redhill; that is,



Plan and elevation of a rod mill for grinding.

the sand is mixed with the pulverised live lime and allowed to stand in a silo for at least 24 hours, giving a most effective slaking by the natural moisture of the sand. Average proportions of the mixture are 85% sand, 8% lime, and 7% moisture (in combination). For the very best-quality brick, however, a rod mill is used to give a further intimate mixture of the sand and lime, before compressing to the brick shapes in high-pressure presses and heating in the long, cylindrical autoclaves for, say, 4–8 hours with live steam at 120–160 lb. per sq. in. gauge pressure.

It will be remembered, of course, that a rod mill is essentially a horizontal or slightly inclined slowly rotating steel cylinder containing a large number of loose steel rods of different diameters extending for nearly the full length, which roll over on one another and grind the material. In the Sutcliffe-Speakman mills the rods are of high carbon steel, to prevent warping, bending, and non-uniform wear, varying from $1\frac{3}{4}$–4 in. diameter. Also the cylinder or shell is constructed of heavy double, steel plating, double riveted with cast-steel flanges. The inner lining is composed of lipped manganese steel plates; these lips or projections during the rotation of the mill lifting up the heavy loose rods and allowing them to fall down again, thus increasing the efficiency of the grinding.

Two general types also are supplied, the first of which is carried in heavy trunnion bearings at each end, while in the second outer smooth-polished steel runner rings or tyres are used, fixed round the body of the cylinder resting on small-diameter steel rollers. In both cases the drive is by means of a large outer gear wheel encircling the cylinder engaging with a pinion on the driving shaft. Any size of mill can be supplied to suit particular conditions. In general, however, the dimensions vary from a cylinder 8 ft. long and 4 ft. diameter to one 12 ft. long and 6 ft. diameter. In the latter case, for example, the average weight of the loose steel rods is 20 tons, while taking medium-hard quartz as a typical product the capacity is 550 tons per 24 hours, reduced from 1 in. size to all through a 20-mesh screen, and 250 tons from $\frac{1}{2}$ in. to a 60-mesh screen, about 160 h.p. being required for the drive. Corresponding figures for the smallest standard size 8 ft. long and 4 ft. diameter are 5 tons of rods, 140 tons per 24 hours from 1 in. to 20-mesh, and 60 tons from $\frac{1}{2}$ in. to 60-mesh, and 45 h.p. for the drive.

INSTITUTE OF METALS.

THE Council has decided to hold the annual meeting of the Institute of Metals on Wednesday and Thursday, March 6 and 7. There will be two morning sessions, as well as an afternoon session on March 6, at all of which papers of metallurgical interest will be presented for discussion. In the evening of March 6 the annual dinner and dance will be held at the Trocadero, and in the afternoon of March 7 there will be a visit to the Battersea Power Station. An additional gathering will take place in the evening of Tuesday, March 5, when a joint meeting will be held with a number of technical institutions to enable members to participate in a discussion of "Problems of Cold Press-work." The discussion will be opened by a paper by Dr. H. J. Gough, F.R.S., Superintendent of the Engineering Department of the National Physical Laboratory, and in the following paper, by Dr. C. H. Desch, F.R.S., Superintendent of the Metallurgy Department of the National Physical Laboratory, there will be summarised the existing information regarding cold pressing from the metallurgist's point of view. This joint meeting, which is being organised in co-operation with the Institution of Automobile Engineers, will be held in the hall of the Royal Geographical Society, and is expected to be attended by about 500 members of a dozen societies.

Educational Tour to Germany.

Following the success of last year's educational tour to Belgium, the Council of the Institute of Metals has now completed plans for an educational tour to Germany for junior members of the Institute, college students, and members of staffs of educational and research institutions. The tour will begin on Saturday, April 6, the party being due back in London on Monday, April 15. During the visit, which will be to the Rhineland of Germany, several important works of metallurgical interest—ferrous and non-ferrous—will be inspected. Opportunities will also be afforded to meet German students, as well as to see something of the beauties of the Rhine. The cost of the tour is expected to be approximately £12.

Annual May Lecture.

Professor W. L. Bragg, F.R.S., is to deliver the twenty-fifth annual May lecture of the Institute of Metals on Wednesday, May 8. He has chosen as his subject "The Atomic Arrangement of Metals and Alloys." It is interesting to recall that Professor Bragg's father, Sir William Bragg, F.R.S., delivered the sixth May lecture in 1916, on the subject of "X-rays and Crystal Structure, with Special Reference to Certain Metals."

Autumn Meeting in Newcastle-on-Tyne.

The Institute's twenty-seventh annual autumn meeting will be held in Newcastle-on-Tyne from Monday, September 9, until Thursday, September 12. This will be the first occasion on which the Institute has revisited Newcastle since its first meeting there in 1911. The members will receive a welcome from the Lord Mayor; sessions for the reading and discussion of papers will be held, and visits to works will be made.

STEEL-MAKING ALLOYS

By W. F. Rowden.

Certain elements have a considerable influence on steel; in application their primary object may be as purifying agents, or, when alloyed, to confer on the steel certain desirable qualities. Because of their usefulness in steel manufacture, these elements have an importance that is out of proportion to their volume. This was appreciated in a recent paper by the author before the Manchester Metallurgical Society, when the functions of a number of these elements were discussed and the manufacture of a selected alloy steel described, much of which is given in this article.

By courtesy of English Steel Corporation, Ltd.

Casting a large ingot.

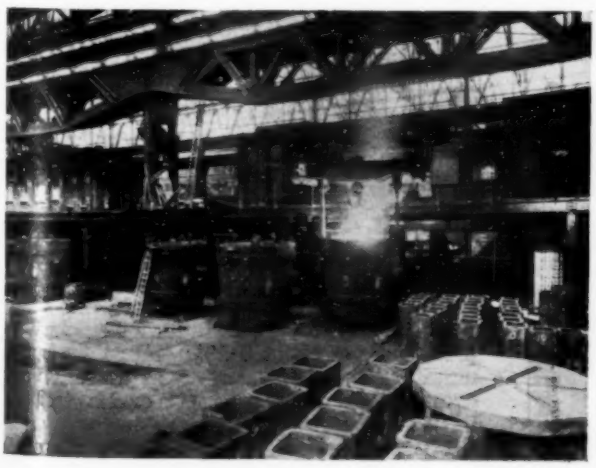
WHAT are sometimes known as "Special," but more generally as alloy steels contain, in addition to carbon, varying quantities of one or more elements, such as aluminium, beryllium, chromium, cobalt, copper, magnesium, manganese, molybdenum, nickel, niobium, selenium, silicon, sulphur, tantalum, titanium, tungsten, uranium, vanadium and zirconium. The inclusion of carbon, silicon and manganese as steel-making elements may be questioned. Normally, the addition of these elements does not constitute an alloy steel, but their addition is necessary, thus, they come within the scope of this article. All these elements have an influence on the steel; some are primarily scavengers and improve the quality of the steel by removing the products of oxidation, others, on the other hand, definitely impart desirable qualities to the steel in which they are alloyed. In order to consider these elements it will be advantageous to give a short account of the form in which they are supplied to the steel-maker, together with brief remarks on the functions of each.

Aluminium.—Added in the form of notched bars, pellets or granular form. The addition may be made in the ladle or in the moulds. Used principally as a deoxidiser. In percentages such as 1% or above, this element is introduced in the nitrogen-hardened steels of the Nitralloy type. There are objections to aluminium, in that there is a danger of the formation of non-metallic impurities, and for this reason it is not used as a deoxidiser in high-grade steels. A recent use of aluminium is with nickel and iron for permanent magnets.

Beryllium.—This element is very expensive, and comparatively little work has been done in connection with its addition to steel. A work of recent note is the joint research of the late Mr. J. H. S. Dickinson and Dr. W. H. Hatfield. This work was in the nature of a preliminary investigation. They conclude that the influence of beryllium justifies further investigation in suggested directions.

Tapping a 60-ton acid open-hearth furnace.

By courtesy of English Steel Corporation, Ltd.



Carbon.—Carbon is added in the furnace as pig iron or speigel-eisen—a ferro alloy of carbon and manganese, containing 4% carbon and 10 to 20% manganese. Anthracite is also frequently added inthe ladle. Of all the elements added to steel, carbon is perhaps the most effective and valuable. It increases the tensile strength and hardness very considerably, but at some sacrifice of ductility, that is, reduction of area and elongation. Toughness is also adversely effected as shown by the Izod impact test.

Chromium.—Chromium is added in the form of ferro chrome. There are a considerable number of ferro chromes available, ranging from the carbon free type to those containing 8 to 10% carbon, the chromium content being about 60% in each case. The carbon-free type is used where it is desired to add a considerable percentage of chromium without increasing the carbon content, such for example, as in stainless irons and steels. The carbon-free type is more expensive than the high carbon ferro chromes. Chromium forms carbides, which are extremely hard, consequently the hardness of steel is markedly increased. Chromium also has the effect of promoting depth hardening and air hardening. When present to the extent of 5% and upwards, valuable corrosion and heat resisting properties are obtained by its inclusion, as for instance in stainless and heat-resisting steels.

Cobalt.—Supplied as cobalt metal, and is added in the furnace or crucible. Cobalt is used as a constituent in high speed steel, where it has the effect of retaining the cutting properties at high temperatures. When present to the extent of some 35% along with iron, a series of valuable alloys are obtained, which have remarkable magnetic properties, and it is therefore used extensively in permanent magnets for this reason. It is possible, however, that the future may see the aluminium-nickel-iron alloys superseding the present cobalt magnets.

Copper.—Copper is added in the form of sheet, bar or copper scrap. Until recently copper was regarded as an impurity, and an acceptance limit of copper content still holds good where high-grade steels are concerned. It is

used, however, in some forms of constructional steels to give increased resistance to corrosion, being present usually to the extent of 0·50%. With this percentage, the tensile strength is slightly increased. It is also used in conjunction with other elements such for example as chromium and molybdenum in certain constructional and tube steels.

Magnesium.—The addition of magnesium to steel is not an easy matter, and developments in finding a satisfactory method of addition are in progress. Magnesium is claimed to improve the forging properties of the austenitic steels when present even in amounts as small as 0·1%.

Manganese.—When the manganese content does not exceed about 2%, the addition of manganese is effected by ferro manganese. This contains about 80% manganese and 1 to 5% carbon, the addition being made in the furnace or in the ladle, as circumstances and quality of steel permit. With this type of ferro manganese, there is an increase of carbon in the steel, and where the carbon content is limited, and a high manganese is required, use is made of carbon-free ferro manganese or manganese metal. Small percentages of manganese act as a scavenger and also assist in forging and rolling. Nearly all steels therefore contain up to 0·6% manganese. Above this percentage, its effect as an alloy addition is quite marked, and it is for this reason that steels containing some 1·6% manganese have become popular during recent years. This type should not be confused with the well-known manganese wear-resisting steel, which contains some 12% manganese.

Molybdenum.—There are three products made, by which molybdenum may be added. These are carbon-free ferro molybdenum, containing 70 to 80% Mo., calcium molybdate containing about 45% Mo. and molybdenum calcium silicate, known commercially as Molyte, which also contains some 45% Mo. They are used according to the melting practice in use. Molybdenum as an alloying element has become much more widely used during the past few years. Probably it is best known for its property of eliminating temper brittleness. In addition it has a definite effect in improving the mechanical properties, especially where large sections are concerned. Recently its use has extended to steels which are subjected to high temperatures, and here it has the effect of reducing creep. The amount of molybdenum added is usually quite small, generally from 0·3 to 0·6%. A specification recently issued for nitrogen-hardening and forging steels specifies 0·90 to 1·50% molybdenum.

In connection with nitrogen hardening steels, it is interesting to note that this steel does not contain aluminium. It is also of interest to record that an up-ending test appears in this specification. Molybdenum is also used in the austenitic steels for corrosion resistance to the extent of about 4·0%. Some of the latest cutting alloys also employ high percentages of molybdenum.

Nickel.—Nickel is added as a metal which is of 99% and greater purity. It is available in pellets, granular form,

By courtesy of English Steel Corporation, Ltd.

Trepanning a 175-ton ingot after cutting off the head and bottom.

notched bars, etc. The effect of adding nickel in percentages of 1% and above, is to increase the tensile strength and impact value without sacrifice of ductility, or when heat-treated, to give equal tensile strength with increased ductility and toughness. Nickel also assists in promoting depth hardening, and is used in combination with other alloys when large sections are involved. Everyone will be familiar with the general use of nickel in percentages of 5% and above, such as in the stainless steels of Staybrite type, alloys of 25%; Monel metal, etc.

Niobium.—This element up to recently was comparatively unknown as a steel addition, it has just lately come into prominence. Niobium is generally associated with tantalum, and in one form contains 52·0% of niobium accompanied by 22% of tantalum. In the employment of certain steels at high temperatures, a phenomenon known as inter-granular corrosion develops. The introduction of certain percentages of niobium into such steels is stated to be a means of preventing this occurring.

Selenium.—Selenium is added in the form of ferro selenium containing 40% or thereabouts of selenium. The addition being made in the ladle on account of loss due to oxidation. The austenitic nickel-chromium steels are not easy to machine. The addition of selenium to the extent of 0·4% is claimed to give free cutting properties to such steels, without detriment to their established characteristics.

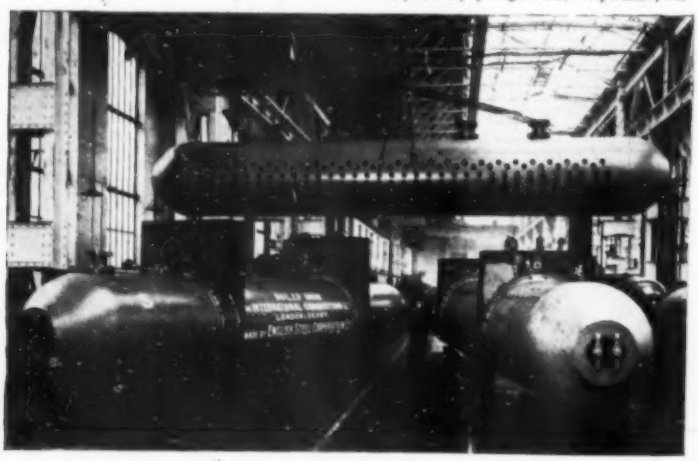
Silicon.—Silicon may be added in several ways, as ferro silicon, silicon manganese, silicon speigel—an alloy of iron silicon and manganese—and also calcium silicide. It is added directly to the furnace at a definite stage in the process, as will be seen later. The main function of silicon is as a deoxidiser, and all steels contain at least 0·1% for this purpose. It is used in the higher percentages as an alloying element, for example, in the silicon-manganese spring steels. In percentages of 4 to 5% in low carbon steel, properties are obtained which make it a valuable steel for the electrical industries.

Sulphur.—Sulphur is added generally as an iron sulphide, for example, iron pyrities. The task of the steel-maker is to keep the sulphur content as low as possible, so it is rather surprising that sulphur should be found on the list of steel alloys. It has, however, a useful property in promoting easy machining, and steels known as free-cutting steels, owe their characteristics to the inclusion of sulphur in percentages of about 0·1%. These steels are unsuitable for purposes where high stresses are encountered, as their properties of this steel are inferior.

Tantalum.—In discussing niobium, reference was made to the tantalum content of the ferro

Large forgings for high-pressure work.

By courtesy of English Steel Corporation, Ltd.



alloy. Tantalum is added by the same means, but in this case the tantalum content is about 50% and the niobium about 20%. As an alloy addition to steel, tantalum is seldom used except perhaps in some abnormal high-speed steel specifications. Little information appears to be available concerning its influence in steel. It has, of course, a large use in the electrical industries in the form of filaments.

Titanium.—Titanium is added in the form of ferro titanium, having a content of 18 to 25% or 35 to 40% titanium. It is sometimes added in the ladle and quite frequently in the moulds during casting. Titanium having a great affinity for oxygen and nitrogen is employed essentially as a scavenger, it being used principally in the cheaper grades of steels. Titanium is also stated to have a beneficial effect in preventing weld decay in the 18% chromium 8% nickel steels.

Tungsten.—Tungsten is available to the steel-maker in a number of forms, for example, as a ferro alloy containing 80% tungsten, tungsten powder and tungsten powder briquettes, both of which contain 99% tungsten. The briquettes, it is interesting to note, have been developed essentially for use in high frequency melting. The melting point of tungsten is about 3,700° C., the melting point of steel is less than half this temperature. It would therefore be thought that it would be difficult to ensure complete uniformity in melting. Actually this is not so, it is not essentially a matter of melting point, but rather one of degree of solubility, and providing sufficient time is left to accomplish this, no difficulties are encountered.

The greatest outlet for tungsten is in high-speed steels. It has valuable properties in heat-resisting steels, and also as a tungsten carbide in a number of special cutting alloys and hard facing materials.

Uranium.—This element has not received very much attention. Uranium is added in the form of a ferro alloy and is claimed to have remarkable deoxidising properties.

Vanadium.—Vanadium is added as ferro vanadium. Owing to its affinity for oxygen, it is usually added in the last stage of the melt and frequently in the ladle. Vanadium, apart from being a deoxidiser, has valuable properties which enable steels to be produced having a high resistance to fatigue, such, for example, as steels for spring leaves; 0·1% vanadium is usually sufficient to obtain such properties. It is also largely used in high-speed steels, and the present tendency is to increase the amount of vanadium from 0·5 up to 1·0%.

Zirconium.—This is added as ferro zirconium. It has a great affinity for oxygen; a fairly substantial loss occurs during addition. Various claims have been made for zirconium as an alloy addition, but at present it is rather difficult to see exactly what benefits may be obtained from small additions of this element.

Heat-Treatment.

In most cases, the full benefit of alloying elements is not obtained unless the steel is subject to some form of heat treatment, and usually the best properties are obtainable, not by single elements, but rather by a combination of a number of elements.

Relative Cost.

The cheapest element to employ is, of course, carbon, and the most expensive, beryllium. To add 0·25% carbon only amounts to pence per ton, but to add the same percentage of beryllium would be about £100 per ton. Between these two elements there is a wide range which may be employed, and the possible combinations are almost unlimited. It may be said that by a careful selection of alloying elements, steels can be obtained which will fulfil definite specifications at a reasonable additional cost.

Selecting a Suitable Steel.

As an example a forging is selected having an outside diameter of 36 in., the wall thickness of which may be 6 to 8 in., length about 40 ft., and having a weight of about 30 tons. Such a forging may be required for a chemical plant, boiler drum, etc. The steel for such a forging is specified to be free from defects, and shall be subject to the usual inspection throughout manufacture; to be of

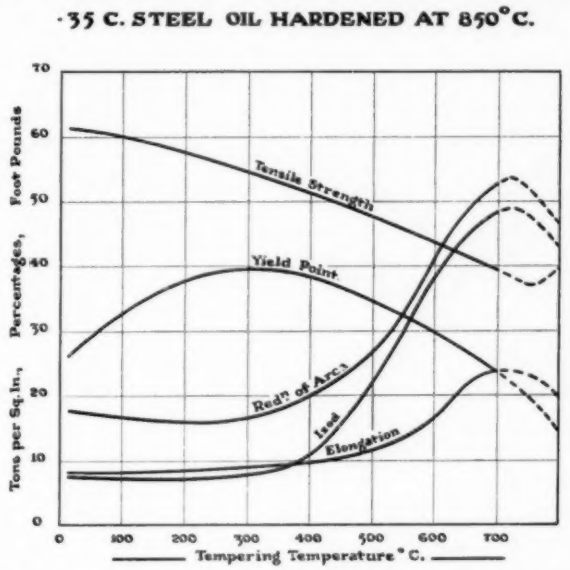


Fig. 1.—Showing the properties of a 0.35 carbon steel from a 1-in. dia. bar.

acid open hearth quality and shall satisfy the following mechanical tests:—

Ultimate Tensile Strength	55·0 tons/sq. in.
Yield Point	40·0 ,, ,, ,,
Elongation in 2	17% min.
Reduction of Area	45% min.
Izod Impact	30 ft. lbs.
Bend	180°

The tests to be taken in a transverse direction at a tangent to the inside of the bore and centre of wall thickness and

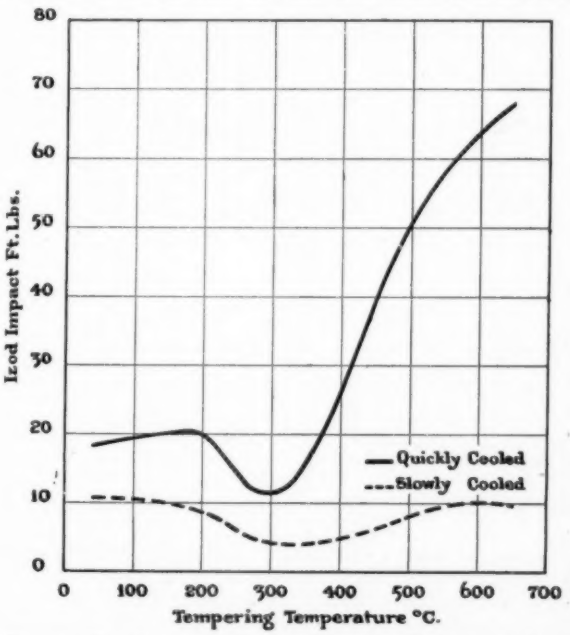


Fig. 2.—Showing the impact values at different tempering temperatures of a nickel-chromium steel.

tested at each end. To obtain such tests, some form of heat treatment is necessary. The most convenient and desirable is oil hardening, followed by tempering.

Carbon Steel.—Carbon steel being the cheapest and easiest to make, let us see what we can do with this element.

Fig. 1 shows the properties of a 0·35% C. steel taken from a 1-in. diameter bar after oil hardening and tempering at the temperatures indicated. The tensile strength required, namely, 55 tons, can be obtained by tempering at

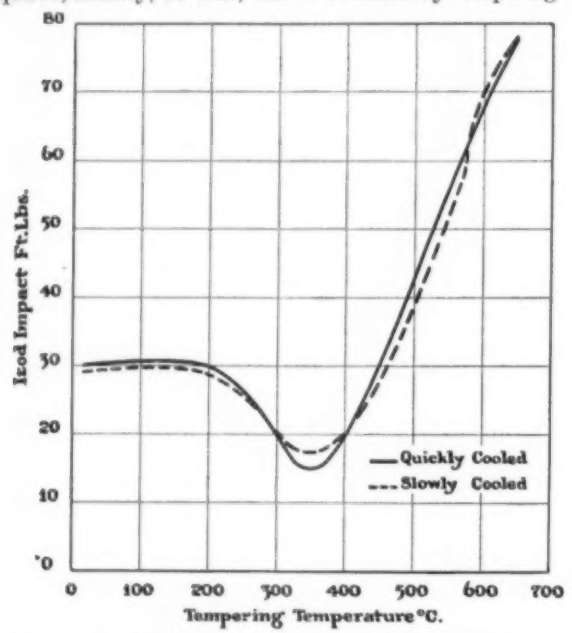


Fig. 3.—Showing the effect on impact values by the addition of a small percentage of molybdenum.

300° C., the other properties, however, fall short of requirements. By further increasing the carbon and correspondingly tempering at a higher temperature, the same strength could be obtained, but the other properties would suffer further deterioration, so it is apparent that some other elements must be added to make up these shortcomings.

Before proceeding further, it would be as well to consider the subject of tempering. It will be noted in the diagram that the steel, when in the fully hardened condition, possesses its maximum strengrh, but the other properties are distinctly poor. The best combination of properties are obtained when the steel is tempered, in this case at between 500°C and 700° C. Above 700° the properties are erratic. This, therefore, is one object of tempering. Another and very important one, is to relieve stresses set up during hardening, and the higher the tempering temperature within limits, the greater is the release of hardening strains which, in this large forging, may be of some magnitude, and further it is possible to cool the forging very slowly from the tempering temperature, then any stresses which may be set up during rapid cooling from the tempering temperature will be avoided.

Consider now for a few moments, the forging It is 40 feet long, it has to be heated to a certain temperature for hardening, and then transferred to the oil tank in a plastic condition. Whatever care may be taken, distortion will take place, either in the actual heating up or during transference or quenching, this if followed by quenching from the tempering temperature will leave a forging which is bent and must be straightened.

Straightening of the forging may be performed cold, if done this way then, to be permanent, a stress must be applied greater than the elastic limit of the material, so that at some point or points, the steel is in a state of stress. If heated up again after tempering for straightening, apart from the waste of fuel, there is the added danger that should the initial tempering temperature be exceeded, the properties will suffer deterioration.

The simplest way will be, if possible, to choose a composition that will allow of the forging being straightened as it cools down from the tempering temperature. The composition therefore should be such as will—

1. Permit the highest tempering temperature to be used in order to secure the best all round combination of properties,
2. Allow slow cooling from the tempering temperature, in order to remove internal stresses and facilitate straightening.

Continuing now with the building up of the required composition, the carbon content being fixed at about 0·35%, all the mechanical properties are required to be raised, and they have to be obtained within a restricted tempering range.

Alloy Additions.

How far can the low priced alloys assist in developing suitable properties ? Experience has shown that chromium if used in a certain percentage gives an air hardening tendency, this occurs about 0·90% to 1·0%, so, in order to avoid any possibilities of air hardening, the chromium will be kept below this percentage, and 0·70 to 0·80% will be added. The effect of adding this amount is most marked ; the tensile strength and yield point is increased, the ductility remains, however, unchanged. But a feature is disclosed in slow cooling from the tempering temperature, in that the Izod impact figure is considerably lower than in the plain carbon steel.

Chromium is known as having the property of promoting depth hardening, and as the forging is of large cross section, it will be retained and other means found to improve the impact. Normally, 0·40% to 0·60% manganese is included in all steels, the effect of increasing this to 1·5% will be considered. This percentage gives a further improvement in the mechanical strength and ductility, but again on slow cooling, the impact value is further reduced, so that for the present, the manganese will be retained at 0·60%.

All these tests of mechanical properties just as in the case of the carbon steel have been made on 1-in. diameter bars, but it must be remembered that the section being

MASS EFFECT GRAPH OF 3% NICKEL STEEL

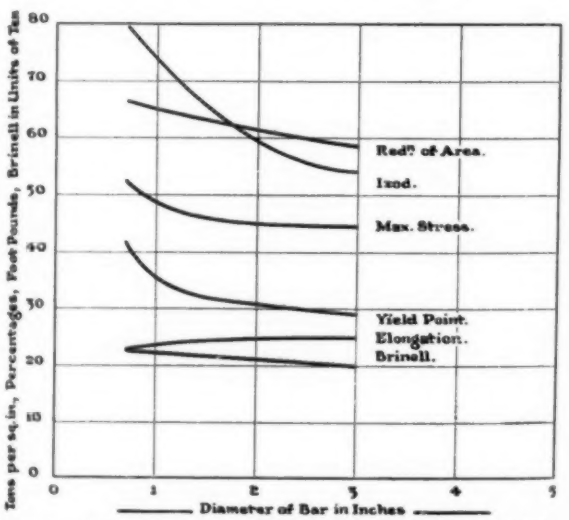


Fig. 4.—Showing the properties of a heat-treated 3% nickel steel.

dealt with is considerably greater. Tests on larger sections show that the properties of a carbon steel on larger sections show a very marked falling off. The effect of chromium in this direction on tests on larger sections show a very distinct improvement.

Nickel being known to possess the property of giving increased toughness and ductility, and in combination with chromium assists in obtaining greater uniformity of properties in large sections is next tried. The effect of 1·0, 2·0 and 3·0% is examined, and it is found that 3·0% gives a great improvement, in ductility. The depth hardening properties are also improved on larger sections, but instead of finding an increase in toughness or impact, the value

has dropped to nearly zero when slow cooled from the tempering temperature. Clearly before proceeding further, the impact value will have to be considered. It is notable in dealing with the composition now arrived at, namely, C. 0·35; Cr. 0·8; Ni. 3·0; Mn. 0·60, that samples cooled quickly from the tempering temperature show high impact values compared with those cooled slowly. This difference in impact values is known as temper brittleness.

Fig. 2 shows the impact values at different tempering temperatures of a nickel-chromium steel after cooling slowly and quickly from the tempering temperatures. Objections and disadvantages in quickly cooling from the tempering temperature, have already been mentioned, both from the point of view of the characteristics of the steel and the method of manufacture, and it is highly desirable that temper brittleness should if possible, be, eliminated.

Molybdenum, being known to counteract temper brittleness, the effect of adding a small percentage is tried. Fig. 3 shows the result of adding 0·35%, it will be seen that there is no commercial difference between the value of the impact figures, irrespective of the rate of cooling, temper brittleness has in fact been eliminated. Further when heat treated to the same tensile, the impact is substantially increased, compared with the same steel without molybdenum, the yield point is also increased and a few extra percentages are obtained on reduction of area and elongation. Examination of properties on larger sections show greater uniformity than those obtainable from the nickel-chromium steel.

The properties of a heat-treated 3% nickel steel on different sections are shown in Fig. 4. It will be seen how the properties fall as the section increases. The properties of a nickel-chromium-molybdenum steel of the composition mentioned are shown in Fig. 5. The four diagrams show the properties obtained on different sections at various tempering temperatures. The two lower diagrams give a

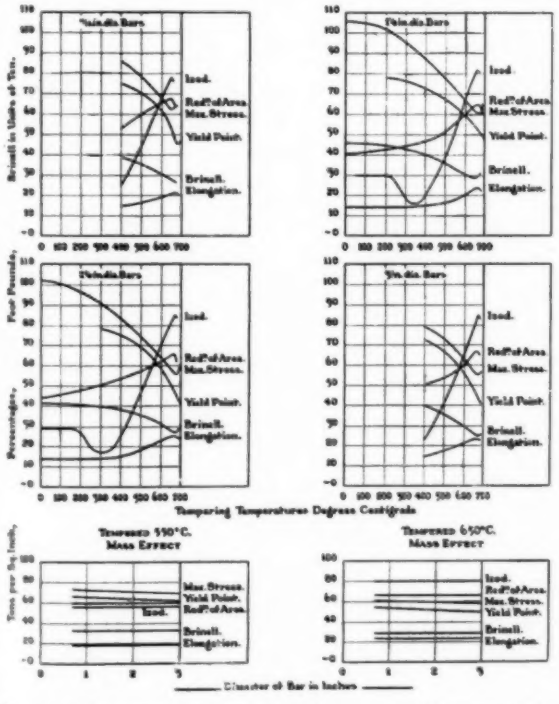

Tempering Temperatures Degrees Centigrade
Tempered 550°C. Mass Effect
Tempered 650°C. Mass Effect
Diameter of Bar in Inches

Fig. 5.—The properties of a nickel-chromium-molybdenum steel.

summary of the properties on different sections after tempering at 550° C. and 650° C. In contrast with the 3.0% nickel steel, the properties of the nickel-chromium-molybdenum steel are practically uniform on different sections. In addition, they show a general all-round improvement. These illustrations demonstrate how misleading tests from a standard 1-in. bar may be when larger sections are concerned.

In heat treating the nickel-chromium-molybdenum steel, it is noted that, to obtain the same tensile with molybdenum present, a tempering temperature some 100° C. higher was necessary, and also longer heating was required. These facts mean that it is possible to reduce hardening stresses to a greater extent with this element present. The usefulness of this element is therefore

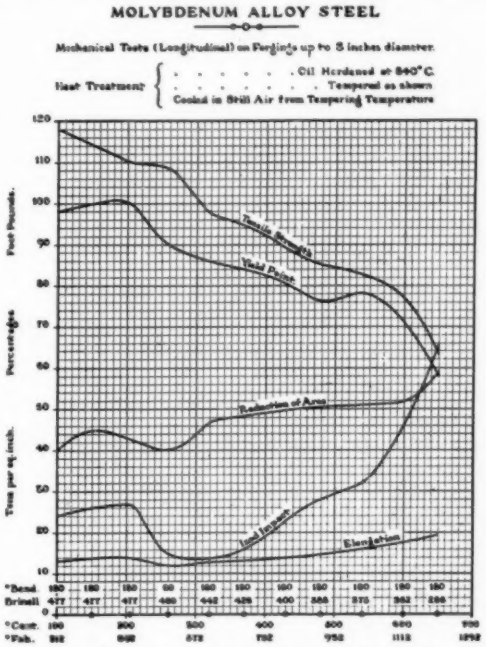


Fig. 6.—Showing the properties of the steel finally selected.

apparent, and the effect of adding a higher percentage is examined,—0·60% is added, and the improvement is substantially increased all round, and properties are practically uniform up to 6-in. section.

Thus we have arrived at the following composition :—C. 0·35; Mn. 0·6; Cr. 0·8; Ni. 3·0; Mo. 0·6.

In alloy, cost neglecting chromium and manganese, which are comparatively inexpensive, nickel will cost about £6 per ton, and molybdenum about £3.

Before finally deciding on this composition, let us go back to the effect of manganese; this proved to be a useful element in improving properties, but at the expense of the impact value. Supposing we take out 1·0% nickel, and bring the Mn. up to 1·60%. It is then found that the properties are equal in all respects, except for the impact. Here is a marked improvement showing that Mo. has had the effect of eliminating the brittleness previously experienced. The final composition with limits is therefore as follows :—C. 0·30 to 0·35; Mn. 1·4 to 1·6; Ni. 1·75 to 2·25; Mo. 0·60 to 0·70; Cr. 0·6 to 0·80%, with phosphorus and sulphur as low as possible, and sufficient silicon to ensure a sound steel, 0·30 max. The physical properties of this composition in the longitudinal direction are shown in Fig. 6. Tests in the transverse direction show that, whilst they are a little lower in value, there is sufficient margin to meet the specification.

Manufacturing a Selected Steel.

The forging is 30 tons in weight, and allowance must be made for a core to be removed; in addition, a feeder head has to be provided, and a discard is made from the bottom of the ingot. Altogether an ingot weighing 60 to 65 tons will be required. A circular ingot is chosen. This type of ingot has a number of advantages, and, in many respects, is easier to cast.

The furnace.—Before contemplating the manufacture of such an important ingot, it is essential first to ensure that the furnace is in perfect condition, the bottom of the furnace should be sound from the last cast, so that the danger of any

part of the bottom coming up, with the attendant liability to absorption of non-metallic inclusions, will be eliminated as far as possible.

The charge.—Assuming that no alloy scrap is available, carbon steel scrap should be carefully selected of low phosphorus and sulphur content. With scrap a certain percentage of pig is employed, this should be such that on melting the carbon content is about 1 to 1·25%. West Coast pig, for example, is suitable, and 30% will suffice, leaving 70% scrap. The charge is melted down, care being taken to avoid the use of an excessive amount of air, which would tend to give oxidising conditions.

Fig. 7.—An acid open-hearth furnace at Fagersta Works, Sweden, showing the steel boiling.

On clear melting, the steel will usually be cold. Better conditions are obtained by carrying as much gas as the furnace will stand, without damage. After perhaps about an hour, the charge will start to boil, the slag becomes better and the steel hotter. A small amount of ore, say about 2 cwts., may be added to get the steel on a good boil, such as is shown in Fig. 7. After the charge has commenced to boil, nickel and molybdenum are added. Calculations are based on the charged weight, plus an allowance for the additional weight of alloys, which are added, and for all practical purposes full recovery of both nickel and molybdenum is obtained. This recovery also applies in remelted scrap and on account of the additional value of such scrap, care should be taken so that it is not used in charges where these elements are not specified or required. The fact that these elements are recovered has another important advantage in the ultimate cost of the forging. Thus in the case under consideration, an ingot of some 60 tons weight is required to make a forging of 30 tons. If nickel and molybdenum were lost on remelting, then the total cost of these elements would have to be charged on the cost of the forging.

Returning again to the working of the charge, at this stage the carbon content will be about 1·00%, and it is necessary to reduce it to about 0·20%. This is achieved by the use of iron ore, but excessive use of ore must be avoided to prevent the steel becoming highly charged with iron oxide. Should such a condition take place, it is almost impossible to remedy it. During the process of boiling down, the temperature of the steel is regulated, having regard to the type being made, and the dimensions of the ingot or ingots which are to be cast.

Three factors must be closely watched during the process of boiling down. They are the condition of the steel, the slag, and the temperature; on these largely depends the ultimate quality of the steel. When the carbon has reached the desired content, it is necessary to stop further reduction of carbon; this is achieved by the use of silicon, which combines with the oxygen present.

The addition of chromium is followed after the silicon has been added,—a ferro chromium containing 6% to 8% C. and 60% chromium may be used—finally the carbon and manganese are adjusted to the required composition by the employment of ferro manganese and speigel, part of the carbon required having already been obtained from the carbon in the ferro chromium. After allowing sufficient time for the alloys to melt, generally about 30 mins. following the addition of silicon, the bath is well stirred, and a final sample taken, which, if the charge has been properly worked, will be found to be quite sound. The furnace is then tapped.

It is of the utmost importance, if subsequent troubles are to be avoided, to see that all possible precautions are taken for the elimination of loose sand, ganister, etc., during tapping, in the ladle, and in the mould. Theoretically, all such matter should rise to the surface of the steel. In actual practice this does not always happen, cleanliness is therefore of the utmost importance. In addition, ladles, moulds heads, should be thoroughly dry.

A ladle will contain two or three nozzles of different sizes. As the steel is being tapped, the steel maker selects the size of nozzle to be used consistent with the temperature of the steel, and the dimensions of the ingot to be cast. It is not possible to go into full details of casting procedure, but it may be remarked that some of the defects found in steel do not always originate from the actual manufacture in the furnace, but come from the casting pit—hotcasting or running ingots too quickly or a combination of both must be avoided.

The ingot after casting is left in the mould for a certain period, after which it is stripped and transferred to the soaking pit to cool down to normal temperature, which usually takes about 15 days.

The author desires to express his thanks to the General Manager and Chemical staff of High Speed Steel Alloys, Ltd.; Messrs. S. Fox and Co., Ltd.; the English Steel Corporation, Ltd., and also the Fagersta Braks Aktiebolag, Sweden, for their co-operation and assistance.

Development of the Ferrous Alloys Industry in the Soviet Union.

UNDER the second five-year plan the ferrous-alloy industry of the Soviet Union is developing rapidly. The programme provides for an increased production of quality steels to 3·25 million tons, or 16 times existing production, which must comprise 13% of the total production of steel by the end of the plan. Production of ferrous alloys must increase correspondingly, and the Commissariat of Heavy Industry has ordered the Zaporozhstal plant to project and construct a ferro-chrome shop with an annual capacity of 10,000 tons, with production commencing early in 1936. The construction of a ferro-wolfram department with an annual production of 1,500 tons must be started at the same time so as to produce simultaneously. "Spetzstal" (the Trust for the production of quality steel) has been ordered to construct a ferro-molybdenum shop at the Zestaphoni ferrous-alloys plant, also to commence production early in 1936. In pre-revolutionary days Russia, despite its enormous mineral resources, had no ferrous-alloy industry of its own, but during the first five-year plan the initial plants for the production of those alloys essential to the manufacture of quality steels were built.

The U.S.S.R. possesses more than 55% of the world's known deposits of manganese ore. Chiaturi, Transcaucasus, and Nikopol have rich deposits which supply the ferro-alloys plants in Zestaphoni and Zaporozhye with their annual capacity of 230,000 tons. The Chelyabinsk ferrous-alloys plant produces 20,000 tons of ferro-silicon annually, and the Zaporozhye plant 30,000 tons. The expansion of the ferro-chrome industry is an urgent task. Ferro-wolfram was recently produced for the first time at Chelyabinsk, and now that considerable deposits of wolfram and molybdenum ores have been established, heavy industry is in a position to begin the organisation of the production of alloys of the metals on a large scale.

Principles of Heat-Treatment

By a Special Correspondent.

The influence of heat upon the quality and cost of nearly all manufactured products, and the comparatively inefficient methods of heating, cooling nad handling in general use, suggest the need for a better understanding of the underlying principles involved in heat-treatment operations. Rapid progress has been made during recent years in furnace design and construction, but unless the fundamental principles associated with the apparently simple heating and cooling of metals and alloys are understood, the improved mechanisms now available will not give the highest efficiencies possible. In this article the author reviews the principles of heat-treatment in the light of recent developments.

HEAT-TREATMENT is a vital operation in the fabrication of most metal parts which have to possess certain desired properties. Definite fundamental principles are involved in the apparently simple heating and cooling of the metal or alloy, and unless these facts are understood and followed grave damage to the finished article and loss may result. Apart from the need to preserve, as well as possible, the shape, size and skin of the articles being treated, there is a variety of reasons for using controlled heat-treatment. Often it is only desired to relieve internal stresses by heating, although occasion may demand the setting-up of definite stresses. More often the changes brought about by heat-treatment involve changes in the constitution of the metal, by altering the nature, form, size or even the actual distribution of the components of the structure. There is thus need to know how to bring about the requisite diffusion, solution or precipitation of the constituents of the metal or alloy in question before a rational process of heat-treatment can be envisaged, and the appropriate mechanism be employed.

Factors in Heat-Treatment.

Heat-treatment consists mainly in subjecting an article to a definite temperature versus time cycle, which is necessarily divided into, first, heating up; second, maintaining the temperature; and third, cooling off. The variations of these three stages are numerous, and may be complicated by the chemical effect of the atmosphere in which the operation is conducted, as in oxidising to form scale, carburising or nitriding. The changes in the metal during the first stage are influenced by the rate of the heating, so that the medium used is important, so far as it governs this rate, which is usually decreased as the "hold" temperature is reached. Thus, an average rate is not so important as the actual rise at each stage of the heating temperature, and control must be adjusted to the permissible rate to prevent such faults as distortion stresses due to uneven temperature, excessive scaling, contour deterioration, or dangerous grain growth. Consistent with getting a uniform heating, the temperature rise should not be too slow otherwise the heat usefully used in bringing up the heat may be much exceeded by the heat radiation losses, which increase with extended duration of this stage. The shorter the heating cycle, the less the skin changes from contact with the heating medium, but care must be taken to avoid too active a flame, which scales more than a slower-heating with a more neutral atmosphere would do.

"*Holding.*" When the maximum temperature of heat-treatment is attained, a time period is required to complete the work of heating up, first to let the entire mass reach a uniform temperature (except in the unique case of shorterising). This time lapse for uniformity increases considerably with the thickness of the heaviest section, and is greatest if the metal has a low-heat conductivity. A slow rate of heating shortens the final maintaining time to gain uniformity of temperature. Another requirement is that the desired changes in the metal are given time to take place. Such changes include diffusion of unevenly-distributed constituents, and if a worked metal is concerned, the requisite grain growth. Examples of the former are the solution of carbides in steel, and the decomposition of carbides into graphite in malleabilising cast iron. Grain growth, which is responsible for the softening of work-hardened metal when annealed, does not occur to any great extent on heating cast metals which have not been cold worked, except in the iron alloys which recrystallise on heating through the $A c_3$ critical range. Both hot and cold worked metals show considerable grain growth above the recrystallisation temperature, and although a very large grain size is occasionally desired, as in some metals notable for strength at high temperatures, it is best in general to limit the development of excessive grain size, as this leads to various undesirable properties. In the case of steel treatment, the laws of grain growth and diffusion play an important part in determining the maximum temperature attained, and the time of maintaining it, as the best structural changes are those of diffusion, and the grain growth is to be avoided as far as possible, since it is apt to occur in the same temperature range. Metals after severe cold work have their recrystallisation temperature lowered from the temperature required after less severe working, and time is also a factor since recrystallisation is brought about at lower temperatures if longer time is allowed. Temperature rather than time is usually the important factor governing grain size, as grain size soon reaches equilibrium at a given temperature, but time is also of some importance, as it should not be prolonged beyond that needed to produce the structural changes desired.

The diffusion rate increases rapidly with temperature rise, and is rapid in the case of carbon in iron, but slower with substances of large atomic volume, such as phosphorus and similar elements which diffuse very slowly in iron, even at higher temperatures. Diffusion time is increased when the initial structure of the metal is coarse-grained, since the distances through which diffusion takes place is greater than in fine-grained material.

When the aim of the heat-treatment is to effect certain phase changes in the alloy, there are definite limits of temperature within which the required change can occur. This range is defined by the constitutional diagram, and the selected temperature is influenced by the various considerations regarding internal stress, grain growth and diffusion, as well as the practical considerations concerning scaling, distortion and economy of working. Low temperature minimises distortion, but for higher temperatures where softening occurs, jigs to prevent deformation may be used, or even stiffeners may be cast on, and removed after heat-treatment.

Cooling. In the case of pure metals or alloys of a single phase being softened by heat-treatment, the rate of cooling is not important, as no change takes place, and it is only necessary to select the most convenient way, having regard to the production of the best surface of the metal. Quite small percentages of impurities can cause substantial changes in the properties of the metal, as for example, carbon, nitrogen or phosphorus in iron, and necessitate slow cooling even below the critical range. The cooling rate is of greatest importance in deciding the final results when the constitution of the metal being treated is different at the maximum temperature from that which is stable at lower temperatures. Rapid cooling can retain in an

unstable condition the structure produced at the high temperature, as in quenching austenitic steels, and on the other hand, very slow cooling allows the fullest development of the constitution of the alloy which is stable at the lower temperature. Intermediate structures in steel are obtained as in hardening, tempering and normalising by controlled intermediate rates of cooling.

Quenching is a special form of cooling in which the heat is rapidly extracted from the suface. The skin must, therefore, be kept in contact with the cooling medium. The effects of mass must be closely studied to bring about the desired effect. Design must also be modified to account for stresses left by cooling irregular sections. Different quenching media may be used in sequence to produce varying rates of cooling, as in tool steel, which is air cooled before water quenching, to reduce distortion and stress; or an alloy steel which may be water quenched for at definite time, and then removed for cooling in air to prevent cracking.

Method of Applying Heat.

The necessary heat may be imparted to metal by the processes of radiation and conduction, the former being the more important means of heat transfer at high temperatures, and the latter in furnaces operating below 500° C., where circulation of the atmosphere is needed to produce rapid and uniform heating. Other means employed may mean the generation of heat within the metal by the passage of an electric current through contacts, or even generated by induction. Electric resistors are used in the radiation furnaces as a great improvement on the older forms of firing with coal, coke, oil or gas. Certain quick forms of heating use liquid baths of molten lead or salt, and even oil for complete immersion of the treated objects, and lower temperatures may be attained by circulated air or in steam containers.

Fuel-fired Furnaces.— Any desired temperature for heat-treatment can be easily obtained in direct-fired or muffle types of furnace. Refractories and insulating materials are now of such high standard that with proper design, the old-fashioned excessive heat losses are much reduced, although for mechanical parts the heat-resisting metals are used where the temperature limit is about 1,000° C., except where elaborate precautions are taken for water cooling; or the parts are operated in such a way as not to suffer the attack of the full furnace temperature. Most economical firing can be obtained from coal or coke, when regenerative principles are adopted, but by far the most perfect control can be got from oil or gas, the personal element being eliminated as far as possible by means of thermo-static control.

The maintenance of the best atmosphere in the furnace is one of the greatest problems in heat-treatment, as steel and other alloys oxidise and form scale loss even in so-called "neutral" atmospheres. The usual products of combustion are of an oxidising nature, nitrogen alone is neutral, and if hydrogen predominates it is reducing, that is, it will remove, instead of forming oxide scale. Carbon monoxide and hydrocarbons can effect a carburising action, whilst the oxidising gases and also hydrogen produce decarburisation.

The commonest action is oxidising, and all the common metals are affected in this way during heat-treatment, the heat-resisting alloys depend on a thin film of scale for their protection against further oxidation, and protective films of other metals, including chromium, aluminium and silicon, are of use due to their strong affinity for oxygen. Furnaces are now made to contain any desired atmosphere, nitrogen-filled or hydrogen containers being used for bright annealing. Ammonia is of special interest as a cheap source, when suitably decomposed, of a mixed atmosphere of hydrogen and nitrogen.

Electric Resistance Heating of metals by direct passage of current through the object is of limited application, for the reason that only articles of uniform section can be treated, such as wire and strip, or even tubes such as those desired of a definite hardness throughout in aeroplane construction. This form of heating can be used for making bars hot enough for forging, or in sintering tungsten products, and occasionally where uneven heating is required in such non-uniform sections as valve ends to be hardened. Rivets may be heated quickly in this way, or by induction without contacts. As the heat is induced within the metal itself, it is very economical, but care is needed in judging the temperature, since external measurement gives low results. The amount of resistance heating is limited only by the current available, in contrast to external heating where the rate of heating is limited by the heat conductivity of the metal.

Electric Furnace Heating. It was the wide extension of this method of heat-treatment, which by taking account of furnace atmospheres and cutting down external losses, has led to the widest improvement in all forms of thermal operations. It has brought about an entirely new idea of the place of heat-treatment in the works' processes, by placing an almost perfect tool at any desired point in the works routine, without the need of eleborate flues, fuel accommodation and ash removal. It also lends itself most readily to automatic control, and although not necessarily cheap, either in first cost or current consumption, it frequently leads to overall economies which justifies its place in the works. The usual heating element is nichrome, in the form of wire or strip, and less often in the condition of cast segments where replacement may be necessary without stoppage, and very long life has been proved in practice. A very high heating efficiency is got by radiation at the higher temperatures of heat-treatment, and both atmosphere control and insulation to minimise heat losses can be operated with certainty. The principle of heat recuperation, usually only considered possible with fuel-fired furnaces, can be made effective by means of suitable double-ended furnaces with an in- and out-going conveyor system.

Costs. Heat-treatment costs can be determined in an electric furnace outfit by measuring the watt-hour input over a given period, and efficiency is measured from this subtracting the heat absorbed by the charge in that time. The difference is the stand-by losses, and on this basis the actual working costs can be worked out for various rates of production. By contrast, the costs are difficult to determine in fuel-fired furnaces, due to the purchase price being augmented by costs of storage, handling, preparation, waste disposal, etc., whilst changes introduced by incomplete combustion, varying flue gas losses and uncontrolled radiation, convection currents, etc., are difficult to assess.

One important result of the advent of the electric-furnace methods of heat-treatment has been to bring about a much-needed revolution in the attitude of works' managementi towards the whole question of efficiencies. This is particulsrly so in regard to heat losses, and other low heat values returned for outlay. No less valuable has been the complete re-organisation of handling methods in the heat-treatment department, and general mechanical efficiency over and above the more effective application of the heat available for various operations. All the variable factors are not yet quite under control, but the essential principles once grasped can be followed out with greatly improved results.

The introduction of the shielded-arc process of welding inaugurated a new era in welding. It has improved the construction of thousands of metal products and structures and at the same time lowered production costs. Why the shielded-arc produces better welds is admirably explained in a booklet received from The Lincoln Electric Company, which also includes informative and interesting articles on the shielded-arc process of welding. Copies of this booklet are available on application to The Lincoln Electric Company, Cleveland, Ohio, U.S.A.

Non-Ferrous Metal Production

Empire's Growing Independence

The importance of the mineral industries to the Dominions is becoming increasingly manifest; it has kept the wheels of industry turning during a period of extreme difficulty, and assisted the sadly depleted export trade of these countries. Developments in Empire production which have increased operating efficiencies, thus reducing costs, and the closer union between Great Britain and the Dominions, brought about by the Ottawa Conference, has assisted and strengthened marketing arrangements.

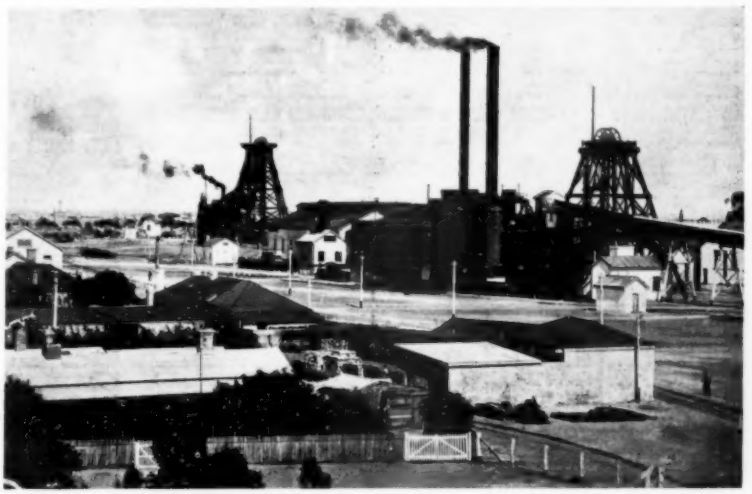
THE general improvement in world conditions, which has been apparent during 1934, has naturally shown a sharp reflection in the Dominion's trade, industry, and business, while the agreements reached at the Ottawa Conference have done much to facilitate the marketing of their products as the returns continue to show. In the majority of instances, however, the advantages these facilities offered would have been unavailing had not the respective countries sought to adjust themselves to the new conditions, resulting from the world depression, by the application of scientific methods and sound constructive policies for the development of their natural resources. While the extension of various Dominion industries has been somewhat outstanding during recent years progress has not been alone in physical development; it has included important developments in metallurgical practice, particularly in connection with the production of such base metals as copper, lead, and zinc.

Probably the greatest progress in this direction has taken place in North Rhodesia, which has jumped to a prominent position among copper-producing countries within the last few years. In 1931, for instance, this country produced only 0·7% of the world's total copper production; in 1932, however, this had been increased to 7·3%, and to 11% in 1933. Further increases have taken place during 1934, and it is confidently expected that the relative proportion will show a further advance.

Having regard to the short time the industry has been in operation in North Rhodesia this record is proof of its inherent strength, and is full of promise. Technical advances have been made in several directions, resulting in more economical operations, and an increase in the effective capacity of the plants, which is now notably larger than that for which they were originally designed. Development has been vigorously pushed forward at the mines, and the Rhokana Corporation some time ago opened a new mining section at Mindola, which is estimated to comprise 25,000,000 tons of ore, averaging 4·25% copper, apart from a large quantity of lower-grade ore.

Progress in this direction however has not been limited to Rhodesia; notable advances have been made in Canada, to which the remarkable expansion of her gold-mining industry, due to the higher price of this metal, has contributed in no small degree. Electrolytic copper of a very high grade is now being produced in Canada, and this is finding its way into many markets, and it may be pointed out that these markets were not available to copper producers until local refineries were built. The presence of gold in association with the base metals has also aided the production of the latter, and has enabled some of Canada's base-metal producers to continue their operations with much more favourable results than otherwise would have been possible. The Horne Mine, for instance, in Quebec, is not only a very important copper producer but also the third largest gold-producing property in the Dominion. The smelter is situated at the mine, and anode copper produced there is shipped to the Canadian Copper Refineries, Montreal East, a company in which the Noranda Mines, Ltd., has controlling interest.

Apart from the association of base metal with gold, two or more metals are frequently in association in the ore; thus, the copper-nickel ore of Sudbury district is the present source of Ontario copper output, while there are relatively few deposits of lead and zinc in which one is found without at least some of the other metal. On the other hand, lead and silver might almost equally well be considered together, since silver is a more common constituent of lead ores. The silver in lead ore, as with gold in pyrite, is not visible in most cases, but it is recovered in refining.



Walaroo Mine, South Australia.

Most of the silver produced in the western part of Canada, for instance, comes from ores which are regarded as ores of lead, zinc, copper, or gold, rather than dominantly silver ores.

Development in the mineral resources of the Dominions is particularly emphasised in the production of copper. During recent years a revolutionary change has been effected, and both Canada and Rhodesia have contributed in no small measure to this change. As recent as 1918 the United States produced nearly 60% of the world's total output of copper. At that time this percentage just about represented the relative quantity of United States copper imported into the United Kingdom; to-day, however, that percentage has been reduced to less than 10%, Canada and Rhodesia accounting for nearly 50% between them. Formerly the United States practically held a monopoly of electrolytic copper, but electrolytic refineries now operating in Canada and Northern Rhodesia have had a considerable influence on exports from these countries.

In the output of zinc great progress is also being made. Canada, for instance, now produces approximately one-eighth of the world's output, and the output for 1934 is

General view of Trail Smelter of Consolidated Mining and Smelting Co., constructed to deal with the ores from the Sullivan Mine in British Columbia.

expected to be the best on record. It is noteworthy that the Consolidated Mining and Smelting Co., of Canada, Ltd., has exceeded the previous record totals of 1930. During the first nine months, for which figures are available, production amounted to 160,000,000 lb., as against 137,000,000 lb. in 1930. In addition, however, the Hudson Bay Mining and Smelting Co., a new producer, is now making upwards of 50,000,000 lb. per annum, while another new producer, the Base Metals Mining Corporation, is exporting lead and zinc concentrates as the result of developments at the Monarch Mine, British Columbia.

Some indication of the increase in Canada's base metal production for 1934, in comparison with 1933, is shown in the following table :—

Metal.	1933. Quantity.	1933. Value.	1934. Quantity.	1934. Value.
	Lb.	$	Lb.	$
Nickel	83,264,500	20,130,500	130,346,500	30,674,000
Copper	299,982,500	21,635,000	367,054,500	26,881,000
Lead	266,475,000	6,373,000	342,811,000	8,357,000
Zinc	199,132,000	6,393,000	300,747,000	9,169,000

In the production of zinc Australia plays an important part. The zinciferous concentrates are produced chiefly in the Broken Hill district of New South Wales, where zincblend forms one of the chief constituents in the enormous deposits of sulphide ores. During the earlier years of mining activity on this field a considerable amount of zinc was left unrecovered in the tailings; improved methods of treatment have long been in use, however, not only in dealing with the ore now treated, but these tailings have been treated and the zinc contents extracted. The real importance of New South Wales as a producer of silver and lead, as well as of zinc, is sometimes overlooked because much of the ore mined is sent for treatment to plants located in other States, but the operation of the Mount Isa smelter has given lead production in Australia a boost to record figures.

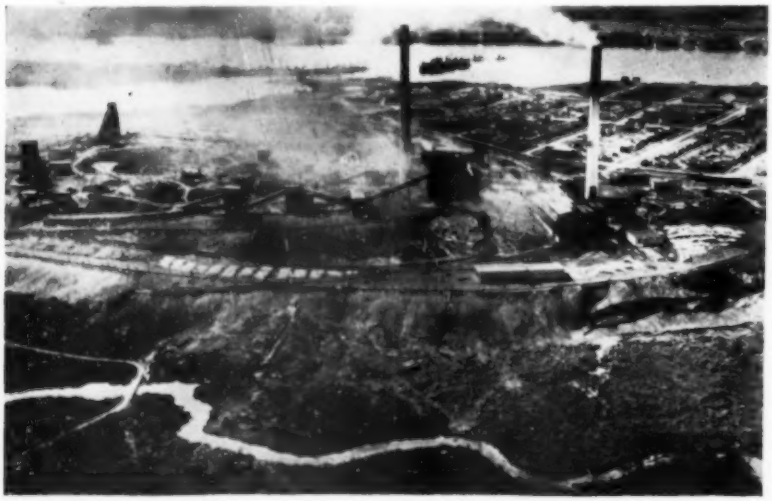
The bulk of Canada's lead production is obtained from the Sullivan Mine, at Kimberley, British Columbia. This State is a very important producer of lead; it contains the largest non-ferrous plant in the world, the Trail smelter, which produces about one-tenth of the world's lead and about one-tenth of the world's zinc. It is controlled by the Consolidated Mining and Smelting Co., of Canada, as also is the Sullivan Mine.

Generally, the trend in the Dominions which produce base metals is towards more complete recovery of the metal in the ores, increased operating efficiencies, and, consequently, lower costs, in all of which considerable success has been attained. The success achieved during recent years, particularly in Canada, has resulted in rather rapid developments of many districts and the exploration of known ore deposits with a view to the expansion of the industry. Despite the difficulties which relatively low prices have imposed on development of new mining properties, improvements have been made at many mines, but it will be appreciated that the owners of these mines have been assisted by the gold content of the ore mined. That strenuous efforts are being made to obtain the best possible advantage from the mineral wealth available is indicated by developments contemplated or in progress.

The International Nickel Company, Ltd., for instance, is now constructing what is believed to be the largest and one of the deepest shafts in Canada at the Creighton Mine, near Sudbury, Ontario. The shaft will be an eight-compartment arrangement, as compared with the seven-compartment one in operation at the Frood Mine. A new head-frame is being erected, whilst the shaft is being raised from the 3,000-ft. level at the No. 5 shaft to surface, and will also be deepened 1,700 ft. Temporary arrangements are to be made to sink the shaft a mile below the surface. The raise is being carried through and will probably be ready to connect with surface shortly. At the Frood Mine a new shaft is being located underground from the 2,400-ft. to 3,200-ft. level to open-up a new ore-body, and new hoist equipment will be installed at the 2,400-ft. level. The International Nickel Company, Ltd., also expects to complete a battery of four new converters at the Copper Cliff (Ontario) smelter early this year.

Falconbridge Nickel Mines, Ltd., are now engaged on the sinking of a five-compartment shaft, 10 ft. × 26 ft., 2,500 ft.

The Noranda Smelter of the Noranda Mines Ltd., Quebec.



east of the existing shaft. Sinking operations may possibly take well over two years before the shaft is placed in service in the feeding of the reduction plant. In the meantime mining and development work proceeds at the increased rate established in 1933, when the new additions to the plant were tuned in. These plant extensions included a 250-ton concentrator, a two-unit sintering plant, and extensions to the smelter building, crushing plant, and ore bins. The existing plant, of two hoisting compartments, is being worked to capacity in raising over 1,000 tons of ore daily, of which 800 tons are going through the mill and smelter. Mining operations are proceeding on all five levels.

British Columbia Nickel Mines, Ltd., in its first progress report, covering operations until the end of October, 1934, show that an ore-body, 140 ft. long by 80 ft. wide, has been cut 1,300 ft. from the tunnel mouth at 500 ft. from the surface. The ore-body shows an average grade of 0·60% nickel and 0·35% copper; the best 5-ft. section having run 1·75% nickel and 0·9% copper. No accurate estimate of blocked-out tonnage has yet been possible. Later reports show that at this property 38 bodies of nickel-bearing pyrrhotite have been located by magneto-metric survey, the results having been confirmed by diamond drilling. A large amount of exploration work in diamond drilling and tunnelling is, however, necessary, and this work is being undertaken under skilled direction. No. 1 tunnel has now been advanced to a distance of well over 4,000 ft., and as soon as the complete intersection of the mountain has been completed, major cross-cutting operations, guided by the results of the magneto-metric survey and the pilot diamond-drilling programme, will be put in hand. The general average of the deposits is stated to be about 1%, although some samples have assayed up to 8%.

Although Saskatchewan has somewhat lagged behind its sister provinces with regard to recent activity in the mineral field, the Province is progressing with what promise to be most important discoveries on the north shore of Lake Athabasca. Rich deposits of gold, silver, nickel, copper, lead, and iron ore have been reported, and the Department of Natural Resources at Regina is having an extremely busy time with applications for miners' licences and the recording of claims. Lake Athabasca is one of the largest in Northern Canada. The lake lies about three-quarters in the province of Saskatchewan and one quarter in Alberta. At Beaver Lake, in north-eastern Saskatchewan, important mineral discoveries are reported, and extensive exploration work is being carried on.

Activities in Chibougamau Area, Quebec.

Whether because of its distance from the scenes of major mining activities to the south, or because of outstanding developments in other sectors of the Canadian mineral front, very little had been heard in recent months of activities in the Chibougamau area in Quebec. In the meantime this outlying mining district (located 300 miles due north of Montreal and 150 miles north of the National Transcontinental branch of the Canadian National Railways), which sprang into prominence in the era of high copper prices, has been witnessing an active campaign of development and exploratory work in which five companies, Ventures, Noranda, Consolidated Smelters, Chibougamau Goldfields, and International Mining Corporation, have been playing the leading roles. There are no producing properties in the area, but prospects for mineral production are regarded as bright. The area may be reached by aeroplane either from St. Félicien, west of Lake St. John, or from Oskelaneo Station, on the line of the Canadian National Railways, and by water route from the latter point.

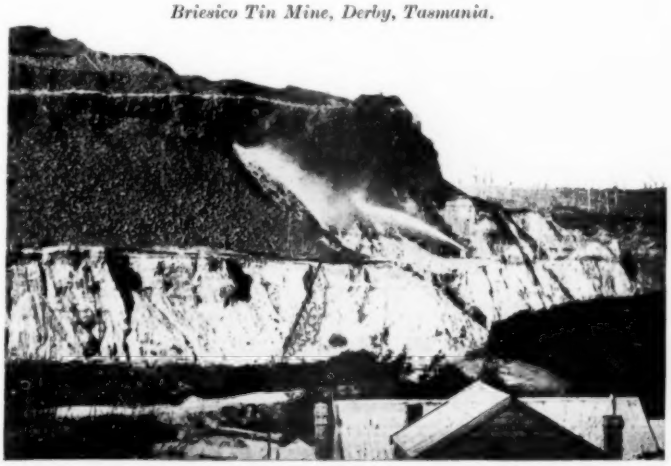
Mount Lyell Copper Mine, Australia.

Early in September of last year the Consolidated Mining and Smelting Company of Canada, Ltd., took over the Chibougamau Goldfield property at Cedar Bay, north of Dore Lake. The principal mineralised zone on the property has been traced for several hundred feet, and has mineralised widths varying from less than a foot to 25 ft. Gold values are distinctly encouraging, and the property has copper-producing possibilities. Consolidated Smelters will sink a 500-ft. prospect shaft during the winter to test the deposit.

Noranda Mines, Ltd., has been carrying out a development campaign on its property a few miles to the north of Dore Lake. The principal showing consists of a well-defined quartz vein, averaging 4 ft. to 5 ft. in width, which has been trenched at short intervals for about a quarter of a mile. The vein has been diamond-drilled to determine its extension under Bourbeau Lake, and to determine its depths. Good values in gold have been reported by Noranda. A second but smaller vein on the east side of the property, similar in character to the main showing, has been trenched for a few hundred feet. Its apparent extension occurs on the adjoining ground to the east, held by the International Mining Corporation.

Highly encouraging surface development work is in progress at the Opemiska (Ventures, Ltd.) property lying 25 miles to the west of Dore Lake. The mineralised zones consist of massive sulphides, high in copper content. At least three distinct mineralised zones with varying widths have been disclosed, and each have been traced several hundred feet along the strike. During the summer work on

Briesico Tin Mine, Derby, Tasmania.



the Campbell property, acquired by Opemiska Mines, Ltd., led to the discovery of another zone of a similar general character to those previously disclosed. This zone has been opened-up for a distance of several hundred feet, and although the showing is narrow it carries appreciable values in gold and silver, and high percentages of copper. About 1,000 ft. to the west, and in line with the discovery on the Campbell property, a mineralised zone about 100 ft. in length has been uncovered. The new discoveries are located about half a mile to the east of the original discovery on the Opemiska property.

It is apparent from the foregoing that in many districts serious attention is being given to the development of new mineral areas, as well as to existing area by companies with years of experience. The exploitation of mineral resources on a large scale at intervals throughout the ages has enabled civilisation to surge forward, and it is asserted with much confidence that some of the Dominions are encouraging a wave of development which will stimulate settlement, industry, and commerce to a remarkable degree.

Book of A.S.T.M. Tentative Standards.

THIS publication, issued each year by the American Society for Testing Materials, is the only volume containing all of the A.S.T.M. tentative specifications, methods of test and definitions of terms covering engineering materials, and the allied testing field. These *tentative* standards, issued as *proposed* standards, embodying the latest thoughts and practices, find important applications throughout industry. The 1934 edition of this publication (1,250 pp.) contains 236 tentative standards. Of these 48 are included for the first time, while some 60 were revised this year and are given in their latest approved form.

New tentative specifications, published for the first time in 1934, cover the following ferrous and non-ferrous materials: Electric-fusion-welded steel pipe for high-temperature and high-pressure service; alloy-steel castings for valves, flanges, and fittings for service at temperatures from 750 to 1,100 F.; and for the same temperature range, seamless alloy-steel pipe; sheet-copper silicon alloy; copper-silicon alloy rods, bars, and shapes, and plates and sheets; also magnesium-base alloy ingot for remelting, and magnesium-base alloy die castings.

In the cementitious, ceramic, and masonry field new standards cover portland cement mortars (compressive strength test), sodium silicate for curing concrete, ground fire-clay, refractories for the construction of incinerators, and structural clay tile (sampling and testing). Other specifications, which have been included for the first time, cover such important materials as fuel oils; various types of emulsified asphalts; woollen and worsted yarns; titanium-barium pigment; titanium-calcium pigment; etc.

Extensive revisions have been incorporated in the requirements for cold-rolled strip steel; black and hot-dipped, zinc-coated, welded and seamless steel pipe for ordinary uses; reinforced and non-reinforced concrete sewer pipe; timber piles; friction tape for general electrical use; and grease wool and allied fibres. In addition to the 236 A.S.T.M. tentative standards the present work includes all proposed revisions of standards, which are published to elicit criticism before final adoption. Changes in 60 standards have been proposed.

To facilitate the use of the book a complete subject index has been included, listing items under the materials and subjects to which they apply: and two tables of contents are given, one listing the standards in the order they appear (grouped under general subjects), and the second listing the items in numeric sequence of serial designations.

Copies in cloth binding at $8·00 each, or in heavy paper cover, $7·00, can be obtained from A.S.T.M. Headquarters, 260 S. Broad Street, Philadelphia, Pa.

FORTHCOMING MEETINGS.

INSTITUTION OF MECHANICAL ENGINEERS.

Jan. 25. "The Care of Modern Steam-generating Plant from the Water Side," by R. J. Glinn, M.I.Mech.E.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.

Jan. 25. "The Relation of Fatigue to Modern Engine Design," by Professor Frederick Bacon, M.A., R. A. MacGregor, and W. S. Burn, M.Sc.

INSTITUTE OF METALS.

BIRMINGHAM SECTION.

Feb. 12. Symposium on Pickling Problems.

LONDON SECTION.

Feb. 14. "The Protection of Metals by Coatings," by W. H. J. Vernon, D.Sc., Ph.D. (Joint meeting with the Electro-platers and Depositors' Technical Society.)

NORTH-EAST COAST SECTION.

Feb. 12. "Melting Furnaces for Non-ferrous Metals," by G. L. Cassidy.

SCOTTISH SECTION.

Feb. 11. "Recent Developments in Electric Furnaces for Non-ferrous Metals," by A. G. Robiette, B.Sc.

Feb. 18. "Recent Advances in Metallurgy," by A. McCance, D.Sc. (Joint meeting with Scottish Branch of Automobile Engineers.)

SHEFFIELD SECTION.

Feb. 8. "The Manufacture of Pewter," by Capt. F. Orme, M.Met.

SWANSEA SECTION.

Feb. 12. "Design of Rolling Mills for Cold-rolling of Metals with Ferrous and Non-ferrous," by C. E. Davies.

INSTITUTE OF BRITISH FOUNDRYMEN.

BIRMINGHAM BRANCH.

Feb. 7. "Suggested Method of Establishing Melting Costs in a Grey Iron Foundry." by H. J. Roe.

EAST MIDLANDS BRANCH.

Jan. 26. "Rotary Furnaces," by W. Scott.

LINCOLNSHIRE SECTION.

Feb. 16. "Some Non-ferrous Foundry Problems," by F. Dunleavy.

LANCASHIRE BRANCH.

Feb. 2. Annual Dinner.

Feb. 16. "Castings," by W. Machin and M. Oldham.

BURNLEY SECTION.

Feb. 12. "Some Notes on Steel Moulding," by A. Benfield.

PRESTON SECTION.

Feb. 6. "Some Impressions of Foundries in the United States of America," by T. Makemson.

LONDON BRANCH.

Feb. 6. "Spraying of Cores and Castings," by A. Roger.

MIDDLESBROUGH BRANCH.

Feb. 8. "Ingot Moulds, Bottoms and Slag Ladles," by J. Blakiston, A.M.I.Mech.E.

NEWCASTLE-ON-TYNE BRANCH.

Jan. 26. "Commercial Moulding Sand Control for the Tyneside Founder," by F. Hudson.

SCOTTISH BRANCH.

Jan. 26. "The Use of Sodium Carbonate in the Iron and Steel Industries," by N. L. Evans, B.Sc., A.I.C.

FALKIRK SECTION.

Feb. 2. "Modern Sand Control in the Foundry," by H. Cowan, B.Sc.

SHEFFIELD BRANCH.

Feb. 15. "Report of Sub-Committee on Cast Iron of the Technical Committee," presented by the Convener, P. A. Russell, B.Sc.

WALES AND MONMOUTH BRANCH.

Jan. 26. "Loam Moulding," by J. J. McClelland.

Feb. 16. "Synthetic Moulding Sands," by J. J. Sheehan, A.R.C.Sc.I., A.I.C.

MANCHESTER METALLURGICAL SOCIETY.

Feb. 6. "Fuel Economy," by W. Goldsbrough.

BIRMINGHAM METALLURGICAL SOCIETY.

Jan. 22. "Defects and Failures," by Dr. J. W. Jenkins.

Feb. 19. "Some Melting and Casting Methods for Copper and Copper Alloys," by W. I. Braziner.

SOCIETY OF CHEMICAL INDUSTRY.

BIRMINGHAM SECTION.

Jan. 21. "Metals in the Food Industry," by N. D. Sylvester.

Aluminium in the Chemical Industry

The advantages of aluminium as a structural material for the chemical industry result from its high resistance to corrosion by many corrosive media, the colourless nontoxic character of its corrosion products and their inability to catalyse oxidation or other changes, and the combination of lightness, strength and high thermal and electrical conductivity.

THE use of aluminium as a structural material has made rapid strides during recent years. Its applications are so diverse that it may be said to take part in some form or other in nearly every modern industry. It is used to a considerable extent in the manufacture of aeroplanes and for parts of the equipment of battleships; doors and furniture; for the filling material for fireworks and for the construction of electric cables. Its lightness is of chief importance in the transport industries. For the transport of liquids, for instance, aluminium has a number of very definite advantages. For use with foodstuff and various chemical liquids, corrosion and hygienic qualities of the metal are advantageous, in addition to the weight reduction. Thus for many years aluminium has been associated with the bulk transport of milk. Aluminium tankers are now also used for petrol and oil. In this country pure metal is chiefly used for tank construction, whereas in the U.S.A. and France, an aluminium manganese alloy is used, which permits a small decrease in metal thickness on account of its higher strength.

The application of aluminium in the chemical industry is developing gradually. As a structural material in this industry its chief advantage lies in its resistance to corrosion by certain chemicals and the character of the corrosion products formed. In a recent discussion on the subject, F. C. Frary[1] states that while the metal itself is very active chemically, it is always (except when amalgamated) covered with a thin adherent, naturally formed coating of its oxide. This is inert chemically and insoluble in some reagents—particularly most organic liquids, distilled water, and many organic acids. For certain purposes it is advantageous to produce a thicker oxide coat by anodic treatment in suitable solutions and improve the impermeability of the oxide coating by "scaling" treatments, or impregnate the coating with corrosion-inhibiting substances. In other cases—for example, where brine is the corroding agent—special alloys are found to be much more resistant than pure aluminium, and sometimes it is possible to add corrosion inhibitors, such as a dichromate, to the brine without interfering with the process. In most cases, however, the corrosion resistance of aluminium in acid or neutral solutions increases rapidly as the purity of the metal increases. Broadly speaking magnesium, manganese, chromium and possibly antimony are the only alloying elements commonly added to aluminium which do not reduce its corrosion resistance to most chemicals.

One of the important advantages of aluminium lies in the fact that its salts are colourless, and slight corrosion, therefore, does not discolour or stain the materials with which it is in contact, or others with which such materials may later be used. For this reason, aluminium stills, tanks, tank cars, and drums are standard equipment in the synthetic acetic acid industry, and aluminium equipment is becoming increasingly important in the cellulose acetate and the organic solvent industries. The author gives the results of laboratory tests and shows graphically the very slow rate of attack of aluminum at room temperature by acetic acid at all concentrations except the most dilute. But it is noteworthy that at the other end of the curve the rate of attack rises rapidly if even small amounts of acetic anhydride are present. Higher temperatures also increase the rate of attack by the dilute acid. Freedom from discoloration effects is also an important reason for the use of aluminum in the naval stores industry and in varnish making. The stearic acid industry is interested in the same property, and also in the fact that a cake of stearic acid solidified in a properly designed aluminum pan does not adhere to it.

The fact that the corrosion products, in the amounts formed, are nontoxic not only to man and animals, but also to yeasts and other substances used in the fermentation industry, is important—for example, in the dairy industry, the production of citric acid from sucrose and that of gluconic acid from glucose. Aluminium seems to have no specific destructive effect on vitamins, even at elevated temperatures. Moreover, as it forms only one series of salts, aluminium causes no catalytic oxidation effects such as may occur in air in the presence of iron or copper salts. Such catalytic oxidation, in the presence of traces of certain metals, has been shown to be the cause of the development of off flavours in dairy products and may perhaps produce a similar effect in other foods. The fact that aluminium is the only common metal which, in its commercial form, does not appreciably catalyse the decomposition of hydrogen peroxide, accounts for its increasing use in the manufacture and shipment of this chemical. Its inertness toward sulphur, hydrogen sulphide, and organic sulphides is often useful—for example, in pipes for handling molten sulphur from the wells and cars for shipment of lump sulphur, and in the distillation and handling of so-called sour crude oils which are high in sulphur.

Extensive tests have shown that aluminium is inert towards anhydrous sulphur dioxide and ammonia (liquid or gas), and its use is approved in refrigeration units employing these materials. Its good thermal conductivity is of importance in the fins, trays, etc., of refrigerators, and its high reflectivity and low emissivity have made aluminium foil important as a light-weight, non-combustible, and vermin-proof heat insulator for both refrigerated and steam-heated equipment. The high thermal conductivity is valuable in equipment when uniform heat distribution and avoidance of local overheating are important.

Experience in shipping synthetic nitric acid in aluminium containers has shown aluminium to be suitable for acid of 80% concentration or better. The rate of attack by this strong acid is very slow. Small amounts of hydrochloric or sulphuric acids greatly increase the attack, but larger amounts of sulphuric acid reduce it.

Inertness to acid fumes, high moisture-proofing power, and long life in sunlight have made aluminium paint popular in many chemical plants for protection of both wood and metal, and to improve lighting conditions. Even dilute chlorine fumes, as in a cell room, seem not to injure it seriously, but it will not stand a spray of caustic solutions.

In some cases, as in bobbins and spinners for rayon, the combination of light weight with adequate strength and resistance to shock (which causes breaking or chipping in stoneware, etc.) is of importance in addition to the chemical resistance of the metal. The fact that the metal can be cast or wrought in almost all forms and can be welded as well as bolted or screwed together, is an additional advantage in building equipment. A good example of the value of strength and stiffness, combined with chemical resistance, is found in the substitution of aluminium for block tin in the storage and handling of distilled water.

Another interesting physical property was revealed in the mechanical tests of aluminium drums for shipping nitric

1 Francis C. Frary. Paper presented before a meeting of the American Institute Chemical Engineers, Pittsburg, Nov. 1934, and published in Ind. Eng. Chem. Vol. 26, No. 12. pp. 1231/1237.

acid, hydrogen peroxide, etc., where dropping full drums from a considerable height failed to burst them, even when they landed on a rail or I-beam. The low modulus of elasticity and the high ductility of the grade of aluminium employed enabled the drum to absorb the shock and stress of the impact by extensive general deformation rather than by local failure, such as would have occurred in a steel drum. The same property has appeared to advantage when aluminium tank cars or tank trucks have been involved in wrecks, avoiding spillage of their valuable and sometimes dangerous liquid contents.

Aluminium's advantages as a material of construction for the chemical industry are manifold, and its relative cheapness and ease of working make it particularly interesting for the construction of chemical engineering equipment. In its pure form this metal is remarkably ductile, which is indicated by the almost inconceivable shapes to which it may be worked. Drawing, hammering, forging or extrusion, makes it practicable to produce almost any piece of equipment in the wrought metal. Because of the many variable factors, however, which influence the life of aluminium and its behaviour in any chemical process, constultation with experienced manufacturers of chemical equipment is desirable before the design is determined.

Reforming the tap-hole of an open-hearth furnace is accomplished by installing a standard steel pipe at the proper slope and packing a recently developed chrome-base castable refractory between it and the brickwork. The pipe burns out when the heat of steel is tapped.

Expansion of slag on freezing in cracks in metallurgical furnace bottoms and the resultant damage of these hearths or bottoms can be prevented by the addition of 0·5 to 5% borax glass to the slag in the furnace.

Symposium on the Welding of Iron and Steel.

THE Council of the Iron and Steel Institute, with the co-operation of other Societies and Technical Institutes, has decided to hold a symposium on the welding of iron and steel on May 2 and 3 next, in conjunction with the annual meeting of this Institute. The general objects of the symposium will be: (*a*) to review the position of welding in all its individual aspects; (*b*) to obtain knowledge of the problems encountered in welding as employed by the various industries; (*c*) to reveal what research has been or is being undertaken; and, arising out of the above, (*d*) to consider the desirability of taking steps to co-ordinate research work and to stimulate and guide future research, possibly with a view to formulating a national scheme.

The increase in use and importance of the application of welding to construction of all kinds has attracted the attention of responsible bodies in this country, including that of the Department of Scientific and Industrial Research. It has become a matter of national importance that every opportunity shall be given to foster the art of welding, to encourage schemes of research and, as far as possible, to avoid overlapping of research effort.

The Committee appointed by the Council to make the arrangements for organising the symposium, and to collaborate for this purpose with representatives from Societies and Technical Institutes concerned, is composed of Sir Harold Carpenter, F.R.S. (Chairman), Dr. H. J. Gough, M.B.E., F.R.S., Dr. W. H. Hatfield, Mr. James Henderson, Mr. A. McCance, Dr. T. Swinden, and Mr. B. Talbot. A detailed scheme of organisation and a list of papers to be invited has been prepared, and copies of this are available from the Secretary, Mr. K. Headlam-Morley, 28, Victoria Street, London, S.W. 1, who will be glad to supply further information about the symposium, and also to receive offers, suggestions, to contribute papers, and applications to take part in the proceedings.

SINTERING FOR THE BLAST FURNACE.

Two Notable Plants at Dagenham and Corby are Discussed.

THE most modern principles of sintering iron ore smalls, blast furnace dust, mill scale, and other finely divided raw material for the blast furnace, are well represented in this country by two new "Dwight-Lloyd" plants. The first of these, dealing with 700 tons of sintered material per 24 hours, has now been in operation for several months at the Ford Works, Dagenham (on the Thames, near London), the blast furnace having a capacity of 500 tons of pig iron per 24 hours, supplying metal direct for all the castings.

As regards the second plant, this has recently been completed at the Corby steelworks, near Kettering (Northamptonshire), of Messrs. Stewarts and Lloyds, Ltd., the rated capacity being 1,000 tons of sintered material per 24 hours.

In connection with the operation of the blast furnace, the addition of a sintering plant enables all the raw iron forming material in a fine state of division to be utilised to the fullest extent. Unless sintering is carried out, all this valuable small material would have to be wasted, since it is in too fine a state of division to be returned direct to the blast furnace, along with the graded lump iron ore, coke and limestone.

The "Dwight-Lloyd" machine, manufactured by Messrs. Huntington Heberlein and Co., Ltd., of London, consists essentially, it may be remembered, of a long, horizontal, endless travelling chain of metal carriages or pallets, each having a flat floor formed of firebars. On these carriages there is deposited a layer of about 7 in. to 10 in. thick of the mixed finely divided ore and other material, along with coke breeze having the correct proportion of moisture. Ignition is carried out at the commencement of the travel by an overhead combustion chamber or ignition muffle, generally fired with blast furnace or coke oven gas, and the carriages then travel slowly over a series of suction windboxes underneath, connected by trunking to a powerful fan, so that air is pulled through the material downwards to burn the coke breeze. This gives the necessary temperature for sintering, that is, partial melting and agglutination, to take place and the product is discharged from the end of the machine as the carriages, forming part of the chain, travel over and downwards at the end on their return journey empty underneath.

The sintered material discharges over a stationary inclined screen or grizzly, and the small material, below ⅜ in. size, is returned to the sintering plant for re-treatment, while the main bulk in the graded condition is passed direct to the blast furnace, along with the other ingredients.

All the raw products are contained in suitable overhead bunkers, each with a variable speed feeder, delivering to a main conveyer belt, and there is provided a primary rotary cylindrical mixer, and a high level mixer, connected by inclined conveyers, while the required amount of water is added in the second mixer, the final product being discharged on to the sintering machine by means of a special design of "swinging spout" feed.

The size of the machine at the Ford works is 71 ft. 0 in. long, with pallets 6 ft. 0 in. wide, corresponding to 310 sq. ft. effective grate area, while the Corby machine is 93 ft. 0 in. long, with 6 ft. 6 in. pallets and a grate area of 430 sq. ft. In general also the total power consumption is about 15 kw.h. per ton of sinter, and the total operating costs are less than 2s. per ton.

Drilling, reaming and tapping hard steel at blast furnace and steelworks machine shops are accomplished easily by using about 4% sulphur with a cutting oil having a mineral base. For high-carbon and alloy steels, a higher percentage of sulphur is recommended. The life of the tools in some cases has been increased 50 to 75%.

Recent Developments in Tools and Equipment

A New Light Self-Indicating Universal Machine.

FOLLOWING the self-indicating medium and heavy capacity universal testing machine recently developed by Messrs. W. and T. Avery, Ltd., a small portable machine, operating on the same principle, has been built into a single unit. It is standardised in two capacities, 5 tons and 10 tons, and is light, compact, simple to operate, and gives very clear, visible indication.

This new machine, which is illustrated in Fig. 1, is of the hydraulic type. The composite parts, embracing the pumping unit, straining mechanism and load indicating mechanism, are all housed in a small base box. The machine is light and portable, and may be used as a field machine if electric supply is available. The load is applied by means of hydraulic pressure, which is also used as a means for indicating the load.

The control of the machine is positive and extremely simple, merely involving the operation of the handwheel of the control valve. The bottom crosshead A (Fig. 1) is secured to the main ram B, which operates in the cylinder C under pressure from the pump. The columns D support the top crosshead E, which carries the top tension holder F. The bottom tension holder G, is carried upon an intermediate crosshead H, supported upon the short tension rods J, secured in the saddle casting K, which also carries the main cylinder C. The saddle casting is secured to the top of the basebox L.

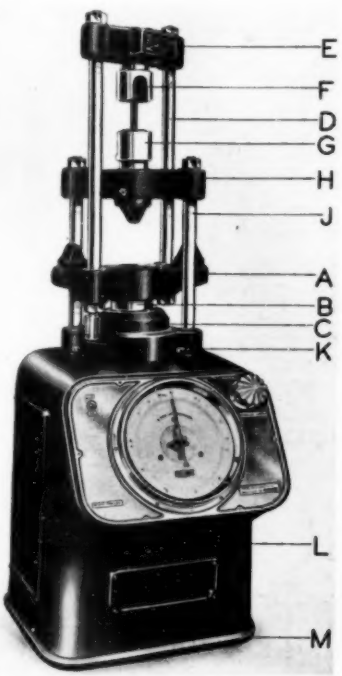


Fig 1.—Self-indicating universal testing machine.

All testing operations are carried out by an upward movement of the cross head A, with its superstructure, relative to the stationary crosshead H. The pump, motor, suction tank and weighing gear are secured to a plate casting M; the base Box L, is merely a shell covering, reinforced at the top to carry the straining cylinder and superstructure. The base box is provided with large inspection holes in three of its four sides, so that any part of the mechanism is readily accessible.

Pumping Unit.—The pump is of the annular piston type. It is of positive action and as oil is used as the pressure medium, it is completely self-lubricating. There are no idle pockets; the path of the fluid through the pump is simple and unidirectional, and is filled and constantly swept by the current of fluid passing. The construction of the pump is of extreme simplicity. The delivery is uniform and pulseless, making the pump eminently suitable for testing machine requirements. All parts are made to fine limit gauges, ensuring low cost of reconditioning.

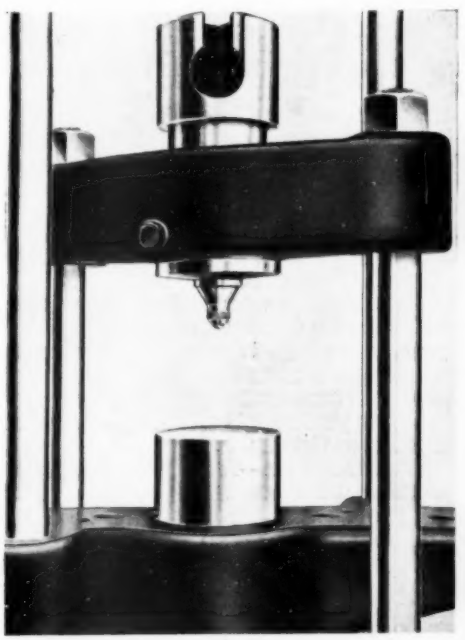
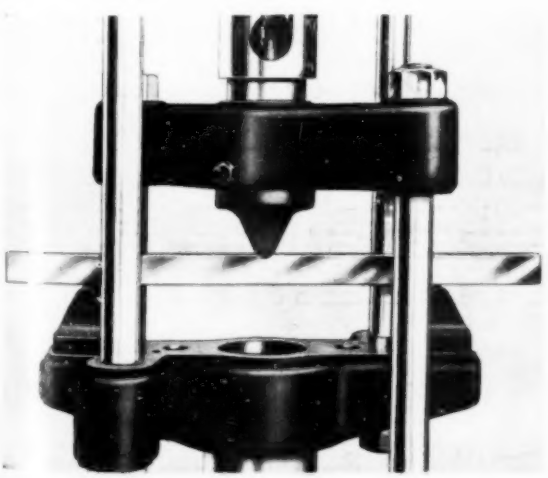


Fig. 3.—Arrangement and fitments for hardness testing.

Fig. 2.—Showing the arrangement for carrying out transverse tests.



The pump is secured to the side of its suction tank, and is driven through gearing by a standard motor running at 1,400 r.p.m., suitable for either alternating or direct current supply, but single phase supply should not be used if another supply is available. The delivery of the pump is capable of moving the ram of the testing machine upwards at approximately ½ in. per minute. The ram returns by gravity. A spring loaded valve is interposed in the pipe line and is set to relieve at a pressure a little above the working pressure, to ensure the machine is not overloaded.

Controls.—These are arranged on an inclined panel, carrying the load-indicating dial at the front of the base box, and consist only of a valve and an ordinary tumbler switch for the motor. The delivery from the pump is conveyed to the main straining cylinder of the testing machine, and is at the same time in connection with the

control valve, which is arranged to control the load at the specimen by regulating the quantity of pressure fluid passed to exhaust.

Straining Mechanism.—The strain is applied to the specimen by means of a single-acting cylinder and ram, rigidly held in a saddle casting secured to the top of the base box. Both cylinder and ram are ground to very fine limits. Packing is not used, and a very small amount of oil is permitted to force its way up between the cylinder and the ram, thus providing forced lubrication. This oil is collected in a recess provided at the top of the straining cylinder and gravitates back to the suction tank. The recess is fitted with a wiper and cover to prevent the ingress of foreign matter.

Tension Test.—The machine is designed for testing tension specimens of both the screwed and headed type. The specimen is positioned in the top holder F, and the bottom holder G. The strain is applied by the upward movement of the main ram and its superstructure, which moves the crosshead E (with its tension holder) away from the stationary crosshead H, carrying the bottom tension holder. Both tension holders are provided with spherical seatings to facilitate correct alignment. Fig. 1 illustrates a tension specimen in position in the holders. Each holder is provided with an outer cover or shell which is free to rotate, so that the holders may be opened for insertion or removal of specimens, or closed for testing by a twist of the cover. The illustration shows the upper holder open and the lower holder closed.

Compression Test.—The crosshead A, fitted to the ram is provided at its centre with a platen upon which compression specimens are positioned. The underside of the intermediate crosshead carrying the bottom tension holder is also fitted with a platen against which a compression specimen is forced during a test. Both platens are marked to assist in the centralization of the specimen. The upper compression platen is held in position by means of a spring-loaded ball which rests in an indent in the stem of the platen.

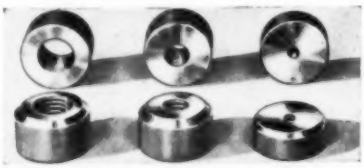
Transverse Test.—The lower crosshead A, is provided with two small castings (known as dogs) to support the transverse specimen, and these can be located to give a span of 6 in. or 12 in. The presser foot is secured in the underside of the crosshead H, by means of a spring-loaded ball. A transverse test is illustrated in Fig. 2. Deflection is measured at the lower portion of the rod D, which extends into the top of the base box, see Fig. 1.

Shear Test.—This is carried out with separate tools positioned between the crossheads used for the compression test. A double shear test is applied to the specimen, which is threaded through bushes fitted to the tools. These bushes are exchangeable.

Hardness Test.—A fitment to carry a 10-mm. ball is provided for this test. It is secured to the underside of the intermediate crosshead. For this test the dial is plainly marked at 3,000 kilos. The specimen is positioned upon the bottom crosshead "A" and brought to contact with the ball, and further until the requisite load has been applied. The diameter of the resulting indentation is measured by a Vee Scale or microscope and referred to a table of hardness numerals. Fig. 3 shows the tools for the hardness test, and also a Vee Scale as supplied for measuring the diameter of the impression.

Load Indicating Mechanism.

The load applied to a specimen is in proportion to the hydraulic pressure in the straining cylinder. The straining cylinder is in connection with a small cylinder, the ram of which is made of fixed proportion to that of the ram of the straining cylinder, to ensure a known reduction in the pull to the lever system. The ram of the small proportional cylinder is arranged to operate in a phosphor bronze liner in its cylinder, and in order to obviate frictional interference in the transmission of the load from this ram, the liner is steadily rotated during a test by worm gearing driven from a shaft geared with the motor driving the pump.



Screwed fitments for tensile testing.

The small proportional cylinder is secured to a casting which is also provided with bearings to support a weighing lever arranged immediately below the small ram. This lever reduces the load and transmits it to a main lever, to which the weighing resistant is attached. The main lever also translates the pull into movement of the spindle which carries the load-indicating pointer, in accordance with regular weighing machine practice.

All loads are indicated upon a dial marked in the form most acceptable to users of testing machines and arranged on the inclined panel of the base box. A second pointer carried from the centre of the glass is provided to indicate the maximum load applied during a test. This pointer is carried round the dial by the live load-indicating pointer, and remains at the highest position reached until reset by hand. The accuracy of the indicated load is plus or minus 1% for loads in excess of 50% of the chart capacity.

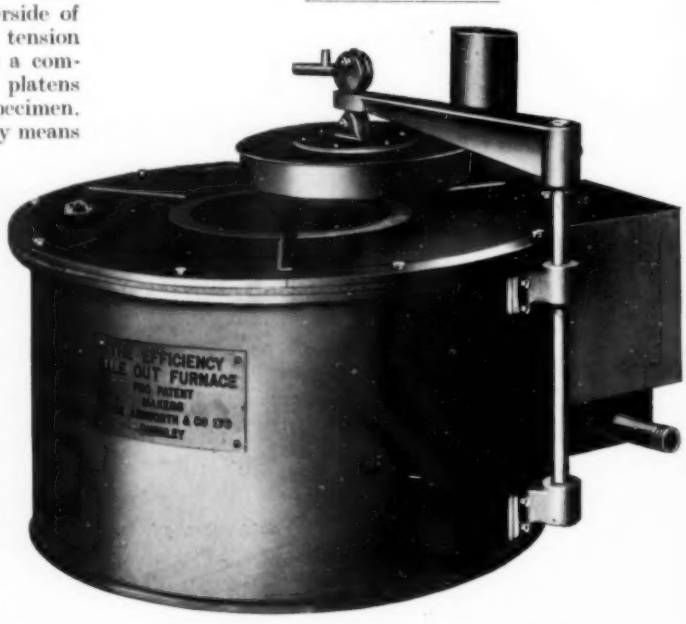
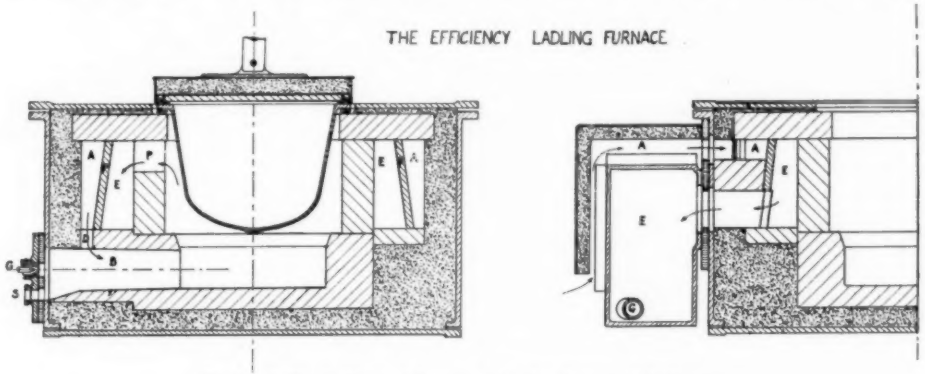


Fig. 1.—New bale-out furnace for aluminium.

Bale-out Furnace for Aluminium.

A NEW furnace, shown in Fig. 1, has been developed for melting and maintaining aluminium at a suitable temperature for bale-out purposes. It is a gas-fired natural draught furnace, which has been used commercially for some time, and is proving both simple in operation and remarkably economical. The furnace uses gas at ordinary town's pressure, and requires a 6-in. diameter flue about 30 ft. high to assist in inducing the air. It is noteworthy that the burner is not of the bunsen type; the air is not mixed with the gas before ignition, as is usual in furnaces of this type; instead, the gas commences to burn as it is used from the needle valve. This gives a softer flame, and no cutting action is experienced either on the pot or the furnace lining.

The furnace consists of a heavy metal casing lined with suitable insulation material, shown dotted in Fig. 2. An inner lining, built of refractory material of the best quality, forms the chamber of the furnace in which the pot for receiving the metal is placed. The air required for combustion is pre-heated to a very high temperature whilst passing through the internal and external recuperators. Thus a large percentage of waste heat is reclaimed. A fusible seal S is provided to allow the metal to run out if the pot breaks. The gas burns at the nozzle G, and its velocity induces the recuperated air via the passage D. The flames enter the main chamber of the furnace tangentially, and swirl round the pot. The waste gases pass out through the exhaust ports P and travel round the furnace in the passage E, thence to the external metal recuperator in which more heat is given up to the incoming air and gas supply.



Sectional illustrations of furnace, showing improved features.

Experience has shown that the maintenance costs of this furnace are extremely low since the best types of refractories are used, and there are no metal parts within the main casing of the furnace. This is supported by the results of a recent test on one of these furnaces, which is given below : —

	August 9, 1934.
Total gas used	= 1,401 cub. ft.
Total weight of aluminium charged	= 440½ lb.
Gas used per lb. of aluminium charged	= 3·18 cub. ft.
Weight of metal charged before any was taken out	= 160 lb.
Time taken to melt this and raise to a temperature of 700° C.	= 1¾ hrs.
Calorific value of gas	= 500 B.T.U's. gr.
Height of steel flue was 24 ft.	

The furnace was using gas at the rate of 311 cub. ft. per hour for 3 hours 47 mins., and thus was then reduced to 46·8 cub. ft. per hour for 4 hours 48 mins., and the damper position altered to suit.

Time.	Weight of Metal Charged Between Periods	Casting Temperature.	Rate of Gas Consumption.
a.m.	Lb.	° C.	Cub. ft. per hr.
8-43 to 10-28	160	700	311
10-28 to 10-45	34	700	311
10-45 to 11-15	55	700	311
11-15 to 11-40	49	700	311
p.m.			
11-40 to 12-15	18½	740	311
12-15 to 12-30	20¾	710	46·8
12-30 to 1-0	10	700	46·8
1-0 to 2-28	27½	700	46·8
2-28 to 3-10	13½	680	46·8
3-10 to 4-0	19½	690	46·8
4-0 to 4-37	12½	700	46·8
4-37 to 5-18	20½	700	46·8

It is claimed that a higher melting rate per hour could have been obtained if a longer flue had been used, but it is apparent from this test that the furnace provides a very economical unit. Town's gas for power purposes varies from 1/6 to 2/6 per 1,000 cub. ft., but even at the higher price the cost per hour is very low, and in comparison with oil fuel, frequently used for bale-out furnaces, shows considerable economy.

It should be mentioned that the burner is provided with a pilot light, which, when the gas has been shut off by the needle valve, continues to burn and will automatically ignite the gas on re-opening the valve. Thus this pilot light can burn continuously and the furnace started immediately. This furnace is patented, and is manufactured by Thomas Ashworth and Co., Ltd., Vulcan Works, Accrington Road, Rosegrove, Burnley.

Indicating and Recording Instruments.

SEVERAL new instruments are being exhibited by Cambridge Instrument Co., Ltd., at the Physical Society Exhibition. Of these considerable interest is attached to a recording which has been designed to meet the need for a reliable but inexpensive instrument for use in applications where it is desired to record only one or, at the most, two temperatures on a chart. It possesses the essential features of our well-known standard thread recorders, but the design has been simplified. Each detail of the construction has been carefully studied with a view to quantity production and consequent reduction in cost, while retaining the maximum accuracy and reliability of working.

Thermo-electric indicator, with increased scale lengths.

The recorder consists essentially of a moving-coil galvanometer, the pointer of which swings above the surface of a clock-driven drum carrying a chart. A thread, impregnated with ink, passes between the pointer and the chart, and once a minute the pointer is automatically depressed, so that it forces the inked thread down on to the chart, forming a permanent record of the position of the

pointer at the moment. As the drum is made to revolve slowly, a continuous temperature record is obtained in the form of a series of closely spaced dots. With this method of recording, pen-friction is entirely avoided. The drum is arranged to make one revolution in 25 hours. The record for the past few hours is always visible, and an engraved scale is fixed over the pointer so that the actual temperature at any moment can be observed.

The complete mechanism is enclosed in a robustly constructed cast-metal case with a glass front. The recorder may be fixed on a wall or other vertical support; alternatively, it may be flush-mounted on a panel if desired. The instrument can be arranged to give records from electrical distance thermometers, thermocouples, Fery pyrometers, or electrical CO_2 meters, or to record electrical quantities—*i.e.*, current, voltage, etc. The records obtained with the two-point model are made clearly distinguishable by different "dotting" intervals.

A 2-point recorder, incorporating the latest modifications.

Modifications to a totally enclosed thermo-electric indicator, which is on view, have resulted in an increased scale length, now 10 in., compared with 7 in. formerly, a larger number of switch points, 48 compared with 24, and an improved type of switchgear. These indicators are available for wall mounting or flush mounting on a panel.

Mention may also be made of a scratch extensometer (De Forest patent), which is designed for recording extensions or compressions in girders, struts, flat metal surfaces, etc.; it consists of two members held together by a friction clip, and capable of moving in one plane in relation to one another. One member carries a polished plate or "target," and the other carries a stylus, which scratches a record of the movement between the members on the plate. The records are viewed by a microscope.

Much interest is also attached to several instruments, including the "Pot" and "Spot" galvanometers, the new dynamometer, an electrolytic bridge, a universal bridge, and a *p*H meter. Development is continually in progress in the manufacture of reliable instruments of this character, and those on view will attract much attention.

We have been informed by Electric Furnace Company, Ltd., that at a recent meeting of the board, a resolution was passed in which it was resolved to declare interim dividends for the half-year ended September 30, 1934, of 3½%, less Income Tax, on the Cumulative Preferred Ordinary shares, being at the rate of 7% per annum, and 2½%, less income Tax, on the Ordinary shares.

The Engineer's Training for Industry.

IN a paper on "The Chemical Engineer and his Training for Industry," read before a meeting of the Manchester Section of the Society of Chemical Industry on January 4, Dr. A. J. V. Underwood urged that the whole question of practical training for the engineer required much more attention than it has received hitherto. The practical training of the chemical engineer, he said, was just as important as his academic training. Whereas the latter was generally carried out systematically, the former was too frequently of a haphazard nature. Practical training generally depended on the particular job a graduate managed to secure on leaving college, and there was a welcome tendency on the part of some large firms to give a systematic practical training to newly engaged staff. Probably the best method was to combine the academic training with practical training under industrial conditions, as was done at some American colleges, but it would probably be more difficult to introduce such a system in this country.

Even more important than the mere acquisition of knowledge, said Dr. Underwood, is the training of the reasoning powers, the faculty of thinking clearly, and the spirit of inquiry.

As a preparation for specific instruction in chemical engineering, a sound foundation of chemistry, mathematics, physics, and general engineering should be provided. It was doubtful whether this could be covered in a three-years course, and probably four years was the minimum. The course should be organised as a part of the faculty of engineering, and not the faculty of chemistry. There is no more justification for including chemical engineering in a department of chemistry than there is for including electrical engineering in a department of physics, remarked Dr. Underwood. The chemical engineer is mainly concerned with physical operations or the physical effects of chemical reactions. The nature of the reaction being given, and its thermal effect being known, the main problems for the chemical engineer, in carrying out the reaction industrially, were physical ones, such as heat transfer, mixing, transportation of fluids or solids. The operations by which the product was finally obtained in the desired form, such as crystallisation, filtration, distillation, drying, grinding, etc., were physical ones. In this example, the choice of materials of contruction was the only question where purely chemical considerations played an important part. Indicating, recording, or regulating apparatus used in the control of the process were again physical rather than chemical.

Laboratory work was a vital part of the chemical engineering training. Its object was not to carry out chemical reactions on a somewhat larger scale than was practicable in a chemical laboratory, but to illustrate the basic principles of the unit operations of chemical engineering and their quantitative application to plant design. Electrical engineering and metallurgy were necessary subjects in a chemical engineering course. The student should also have some training in the use of sources of information, such as technical journals, patent literature, abstract literature, trade catalogues, etc., and as chemical processes were carried out industrially for economic reasons, economic considerations must be clearly brought out.

But when all is said and done, remarked Dr. Underwood, laying down a course of instruction and putting students through it is not a mechanical process of manufacture; and an enormous amount depends on the personality of the teacher who, in addition to the requisite human qualities, must be a man of wide industrial experience.

The New South Wales Government Railways have just placed an order for five power Diesel railcars. Each rail-car, fitted with a 360-h.p. Harland and Wolff engine, will haul three trailers and be capable of 80 miles an hour. Fitted with the latest form of fluid coupling transmission, manufactured by the Hydraulic Coupling and Engineering Company, all gear-changing is entirely eliminated, the control being governed by the hydraulic coupling.

Some Recent Inventions

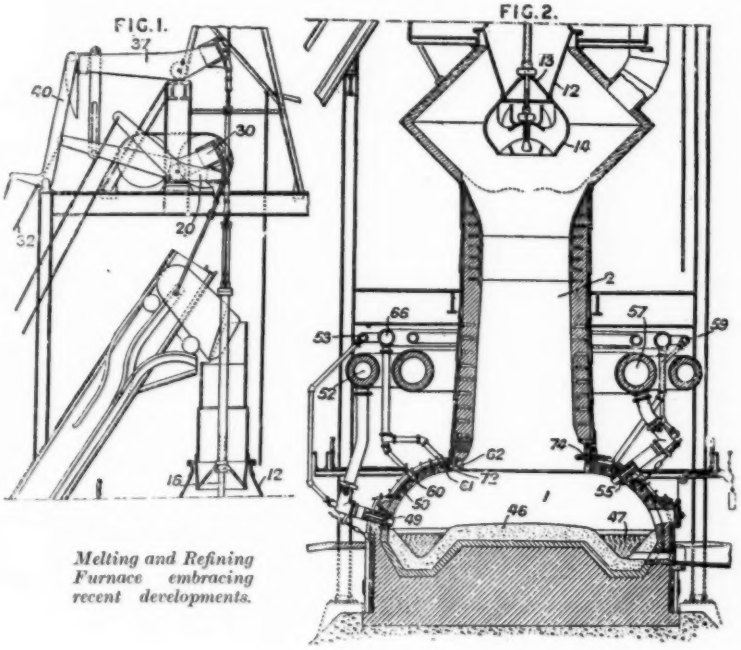
The date given at the end of an abridgement is the date of the acceptance of the complete Specification. Copies of Specifications may be obtained at the Patent Office, Sale Branch, 25, Southampton Buildings, London, W.C. 2, at 1/- each.

Metallurgical Furnaces.

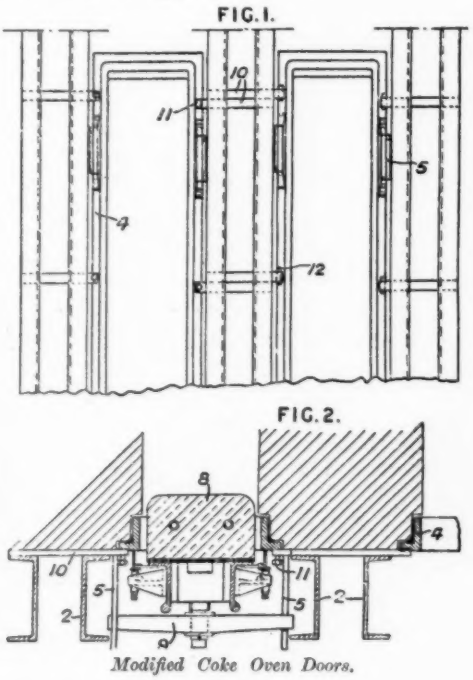
IN a furnace for the reduction of ores, refining of metals, and the manufacture of alloys, of the kind comprising a shaft portion 2 superposed on a hearth portion 1 providing an annular combustion space around the lower part of the column of stock, the hearth portion has an annular metal well 47 around a central raised central part 46, and nozzles 55, 49 for delivering fuel and air on to the column of stock and the metal in the well, respectively. This arrangement allows the metal collected in the well 47 to be refined before it is discharged from the furnace. As shown, the raised portion 46 is of greater area than the lower end of the shaft, and is at such a level that the stock column is supported substantially clear of the metal in the well 47. Mains 53, 59, and 52, 57 supply fuel and air to the nozzles 49, 55, and another main 66 supplies inert cooling gases, which may be waste gases from hot-blast stoves, to nozzles 60, 61. The nozzles 49 may be arranged below the level of the central portion of 46 of the hearth. The domed roof 50 consists of a number of removable sections having metallic outer parts and inwardly extending fins with water-cooling passages. The shaft is supported independently of the hearth portion, and the joint formed by metal rings 62, 72 is such as to allow relative movement between the two parts. The cross-section of the shaft at its lower end can be varied by means of water-cooled slides 74. A modification is described in which the hearth portion has an outer wall connected to the lower end of the shaft by domed roof sections and water-cooled jointing-rings. The burner nozzles are tangentially directed into the combustion space, and radial nozzles for the supply of cooling gases alternate with the upper row of burner nozzles. Should the shaft become choked a portion of the combustion gases from the hearth may be drawn off through the cooling-gas nozzles. In operating the furnace, melting and refining periods are alternated, and during the refining period a reducing atmosphere is maintained by the lower set of burners and a portion of the combustion gases may be withdrawn through the upper set.

Charging.—The feed hopper 12 has an upper bell 16 carried by a bell-crank 20, and a lower bell in two parts 13, 14 suspended separately from bell-cranks 30, 37. In the position shown of the locking-lever 40 the bell-crank 37 is prevented from movement, and the part 13 of the lower bell can be operated to feed the charge to the middle of the furnace by slacking the cable 32. When the lever 40 is moved to release the bell-crank 37, the lower bell moves as a whole to feed the charge to the periphery of the furnace.

414,055. H. A. BRASSERT AND CO., LTD., Brook House, Walbrook, London. (H. A. Brassert and Co., South Michigan Avenue, Chicago, U.S.A.)



Melting and Refining Furnace embracing recent developments.



Modified Coke Oven Doors.

Coke Oven Doors.

IN a closure for coke ovens, comprising a door with a fire-proof inner door bearing on a door frame fixed on the oven masonry, the frame is connected to stays supporting the masonry by detachable retaining members. Retaining plates 10 fit in recesses behind oven stays 2, and the door frame 4 is pressed against the masonry either by screws 11, or by wedges 12. By loosening the securing means and moving aside the plates, the door frame, to which is attached the door 8 by a bolt 9 and hooks 5, can be removed together with the door.

413,971. Dr. C. OTTO AND CO., Ges. Christstrasse, Bochum, Germany.

Refining Copper.

To lower the bismuth content of copper matte molten metallic copper is agitated with the molten copper matte and then allowed to settle out; the molten copper collects the bismuth from the matte. In a method of carrying out the process a molten matte is charged into a converter and blown until a portion of the contents is converted into metallic copper, thorough agitation taking place during the operation. Blowing is then discontinued and the molten copper allowed to settle, carrying the bismuth with it. The purified matte is poured into a second converter and blown to metallic copper. In modified methods molten metallic copper or a proportion of copper oxide may be added to the matte; cuprous sulphide reacts with the oxide producing metallic copper. Specification 15222/02, [*Class* 82 (i)], is referred to.

413,394. ROAN ANTELOPE COPPER MINES, LTD., Selection Trust Buildings, Mason's Avenue, Coleman Street, London. (C. R. WRAITH, Luanshya, Northern Rhodesia.)

New British Chemical Standards.

As a result of a request for standard analysed samples of ferro alloys, Headquarters of British Chemical Standards announces the issue of the first three of a new series, viz. :—

Ferro-tungsten	(80·7% tungsten)
Ferro-molybdenum	(72·1% molybdenum)
Ferro-titanium	(22·8% titanium)

These alloys are in each case of the low-carbon variety, and have been analysed by a ferro-alloy manufacturer, independent chemist, and Sheffield works' chemists.

There is no doubt they will meet a long-felt want by chemists associated with manufacturers and buyers of alloys for special steel making.

The standard samples are issued in bottles containing 25 grms. and 50 grms. of each alloy at a price which it is estimated will eventually cover the cost.

A valuable feature is the certificate of analyses which accompanies each bottle, and records not only the individual tests and the standard figures but also an outline of the methods of analyses employed. This information is of particular value in the case of the ferro-tungsten.

The samples may be obtained direct from Headquarters, 3, Wilson Street, Middlesbrough, or from any of the usual laboratory furnishers.

Use of Electric Furnaces in Industrial Heat Treatment.

(*Continued from page* 64.)

charge is no longer absorbing heat, and has reached furnace temperature. The charge may then be withdrawn or "soaked" for any prescribed time. In this way guessing as to the completion of treatment is eliminated, and there is neither waste of time nor under-treatment.

Nitriding.

The nitriding process for the case-hardening of special steels and irons also calls for a comparatively low temperature, and has made considerable progress in recent years. This process, requiring as it does long treatments at an accurately controlled temperature, is pre-eminently a process for the electric furnace. Box-type furnaces have been specially designed to deal with this process, the hearth being fitted with rollers, so that the nitriding box, duly sealed and connected with an ammonia supply, is readily put into the furnace. The ammonia is slowly passed through the nitriding box containing the charge at a rate which maintains a definite degree of dissociation.

A special type of furnace has been designed to deal with the nitriding process in a rather different manner. This furnace may be described as the inverse of the car or bogie hearth furnace, the hearth or hearths being fixed and the furnace movable. This arrangement makes possible a number of desirable features. It eliminates flexible gas connections, all tubing being permanent; two hearths can be used, so that no time and little stored heat is lost in transferring to the other charge; fans are fitted to circulate the atmosphere, thus ensuring uniformity of temperature, and of ammonia distribution, and the sealing of the boxes is simplified.

With the usual slow current of ammonia gas the degree of dissociation may vary considerably throughout the chamber. There is a liability to form pockets, where little fresh ammonia penetrates, thus causing soft spots. The use of a fan entirely prevents this, but with movable boxes fans cannot be conveniently fitted. The use of fans in nitriding furnaces has been condemned by some as causing soft spots, but this was found to be due to improper gland fitting, allowing air to get into the box. The method results, therefore, in much more uniform nitriding, and the boxes can be used more completely and fully packed without danger of non-uniformity. With this duplex furnace spent ammonia from the container in process is used for flushing out a newly loaded container, or maintaining an inert atmosphere whilst cooling, thus effecting economy of ammonia.

Business Notes and News

Railway Building Programme.

The London Midland and Scottish Railway Company's works and rolling stock programme for 1935 will involve an expenditure of £9,300,000, and will include the provision of 287 locomotives and 175 locomotive boilers, 607 passenger coaches, 20 sleeping cars, 10,050 freight wagons, and two steamships. In addition, the company will renew 600 miles of permanent way and over £1,500,000 will be spent on other miscellaneous railway works.

Of the 287 new locomotives to be introduced, 10 will be similar in type to the four-cylinder 4-6-2 express passenger engine, "Princess Royal," which was placed in service between London and Glasgow in 1933. The scheme provides also for 30 additional three-cylinder 4-6-0 express passenger locomotives, together with 155 4-6-0 mixed-traffic engines, and 20 Diesel-electric shunting locomotives.

All the new locomotives will be of increased unit power compared with the units to be displaced. Since the group came into being 12 years ago the number of different types of locomotives running on the company's metals has been reduced from 393 to 188, while the number superheated has been increased by 2,120, or nearly trebled.

£1,250,000 is to be spent this year on the 607 new passenger coaches. Approximately one-third of the new freight wagons will be fitted with automatic brakes in order that they may operate on express goods services. The 1935 programme also provides for the acquisition of a large number of motor-vehicles for the roads. The expenditure on permanent way renewal will amount to £2,000,000, and will involve the use of 90,000 tons of steel rails, 1,300,000 new sleepers, and 1,210 tons of fishplates.

During the year the L.M.S. fleet of steamships will be augmented by two new vessels, the *Marchioness of Lorne*, and the *Duke of York*. The former will be placed in service on the Clyde, and the latter on the company's Heysham-Belfast route. At Fleetwood Harbour an expenditure of over £85,000 will be incurred on an improvement scheme.

Darlington Benefits.

The building programme of the London and North-Eastern Railway for 1935 includes the construction of 49 engines at the North Road and Stooperdale Works, Darlington, and of nearly 6,000 wagons at the Faverdale Works, Darlington. This is a normal programme, but it is expected to keep the Darlington works fully occupied throughout the year.

Ten of the 49 locomotives are carried over from the 1934 programme, five being six-coupled passenger engines, and the other five four-coupled passenger engines. The 39 engines in the new programme are all six-coupled goods engines. In addition, 24 passenger tank engines are to be converted from four-coupled to six-coupled.

It is understood that 39 passenger coaches, most of a special type, are to be built at York, and that the carry-over from 1934 will keep the locomotive works at Doncaster busy for six months. The 1935 allocation for Doncaster has not yet been revealed.

All-Steel Coaches.

It is noteworthy that the new passenger coaches are not of the all-steel type. Apparently the report of the Government inspector on the Winwick Junction disaster comments unsatisfactorily regarding them. It is agreed that they resist shocks better, but the manner in which they are thrown about after a heavy impact at speed causes greater risks to the passengers than the coach partly constructed of wood.

The Diploma of Ingenieur de l'Ecole Superieure de Fonderie Awarded to an Englishman.

This award has just been conferred on Mr. C. J. Dadswell, who, in 1925, took his B.Sc.(Eng.), London, with first-class honours, and subsequently obtained the degree Ph.D.(Eng.), London, in 1927. Mr. Dadswell was educated at University College, University of London, served his apprenticeship as an engineer, and was for some time attached to the Works Manager's department at the London, Midland and Scottish Railway, Carriage and Wagon Works, Wolverhampton. On coming to Sheffield he spent some time in the melting departments and machine shops of English Steel Corporation.

In 1932 he won the Robert Blair Fellowship, the gift of the London County Council. This enabled him to increase his knowledge of foundry work by visiting foundries in France and Italy, and to take the special course for foundry executives at the Ecole Superieure de Fonderie in Paris. In the final examination at the end of the course Mr. Dadswell came out next to the top. The examination, among other things, entailed the design and layout of a complete foundry, and was followed by an oral examination and the presentation of a thesis, all in French.

To go to France, learn French (particularly technical French), study foundry work in all its aspects at the various foundries in France and Italy, and to sit for the examination in French is no mean achievement, and one on which we heartily congratulate him.

Following his examination Mr. Dadswell visited foundries in Belgium, Luxembourg, and the Saar, and in order to gain still further experience took a job as a moulder in the iron, brass, and steel foundries of Vickers-Armstrong, Ltd., at Barrow. In May this year he was appointed in charge of the Cammell Grimesthorpe Foundry of the English Steel Corporation, Ltd., where we believe he will be able to apply to advantage the splendid experience he has gained.

Increased Duty on Enamelled Ware.

Under an additional import duties order issued by the Treasury on the recommendation of the Import Duties Advistory Committee, Customs duties at the rate of 25% *ad valorem* will be imposed on the following products of vitreous enamelled or stove-enamelled iron or steel, namely, signs of all kinds and hearth-plates and other plates and sheets (not being hollow-ware) of a description commonly used for domestic purposes.

The Committee report that the British manufacturers of these goods have suffered considerably from foreign competition, particularly in regard to enamelled signs and hearth-plates, and prices have been forced to uneconomic levels.

General Electric Increase Capital.

A large majority at a recent extraordinary general meeting of the General Electric Company Ltd., supported a resolution to increase the capital of the company to £9,600,000 by the creation of 2,000,000 new ordinary shares of £1 each. The Rt. Hon. Lord Hirst of Wilton, chairman and managing director of the company, presiding, said there were several reasons for taking this step. Soon after the war it was considered desirable to widen the field of activity of the company; an ambitious scheme was agreed upon, but at that time money conditions were difficult, and the £4,000,000 required for the purpose was principally supplied by a debenture issue. Since then money conditions have become easier, and the debenture interest has been reduced by two conversion processes from 7 to 4¼%. It is felt, however, that debentures are an indebtedness which a virile and prosperous company should not have hanging over it. The opportunity has now arisen, and it is apparent that the shareholders are in sympathy with the desire.

The new shares are to be offered to holders of the 4¼% debenture stock at a price around the current market price at the time of issue. The present price of the ordinary shares is 50s. 6d., but the actual terms of the exchange have yet to be fixed.

Russia's Need of Technical Men.

Great stress is now being placed on the need for trained technicians by the Soviet Union. A new policy of men before machines has been laid down by Stalin, the Soviet leader, in which the development of technicians is to be given priority to the piling up of the number of machines. In a speech embracing this declaration, Stalin admitted that the rapid manner in which the five-year plan had been carried out had resulted in much destruction of machinery. Considerable discussion among about 50 experts assembled at the Kremlin followed his speech, particularly in relation to the means for increasing the production of steel, which Stalin declared was the present paramount necessity.

This is significant as indicating the future policy of the Soviet Union. Apparently it is intended to stress the quality of Soviet goods, which foreign experts have hitherto considered very low. It is gradually being recognised that the best of plant and machinery needs some degree of skill to obtain the best results, and it has now become necessary to protect each able and understanding worker and cherish and cultivate him.

New Coal-Oil Plant.

The construction of a new coal-oil plant has been commenced near the Vane Tempest Colliery, Seaham Harbour, on which an outlay of approximately £5,000,000 is contemplated during the next five years. It is proposed to raise raw coal, pulverise it, mix it with crude oil, and heat the mixture in retorts to a temperature of 550° C. The products obtained are semi-coke, petrol and various chemical by-products, practically the whole of which is usable.

The complete plant will cover 59 acres of land, but it is designed in unit form and expansion will take place by 125-ton units. It is understood that the first plant will consist of four units processing 500 tons of coal per day. It is hoped to extend to 1,500 tons per day, and an option has been obtained on about 240 acres of land adjoining the present site. The 500-ton scheme will cost approximately £225,000, and it is expected that the plant will be in operation towards the end of this year. The retorts are being made to the design of Mr. H. P. Stephenson. The plant will be the most modern of its kind, and it is stated that in the course of the next five years an expenditure of £5,000,000 may be reasonably expected.

The illustration shows the obverse and reverse of the new 5-franc pure nickel coins which were issued in France on November 3. They have been designed by Monsieur Lavrillier, and are 31 mm.in diameter, with a weight of 1½ grammes. 45,000,000 of these coins have so far been released, and they are to replace the provisional issue of 5-franc pieces which were issued in October, 1933. These coins were half the weight of the new ones. They will be recalled at some future date for re-minting.

Desert Pipe Line Inaugurated.

The great pipe-line which is to bring the oil of Iraq across the desert to the Mediterranean, has just been inaugurated with much ceremony. This gigantic undertaking, the work of an international company with British, French, Dutch, and American capital, has cost 10 millions sterling, and has occupied the engineers for over seven years. The 1,150 miles of piping will tap an oilfield regarded by some experts as potentially one of the richest in the world. This pipe-line system has been built from Kirkuk to the Mediterranean, where it ends at Tripoli, in Syria, and Haifa, in Palestine. Its construction can rightly be referred to as a notable engineering achievement, because the difficulties encountered were enormous.

There is little doubt of the abundance of oil in the area of 32,000 square miles east of the Tigris which, by its concession from the Iraq Government, the Iraq Petroleum Company has the right to exploit. Some 42 wells have been bored, each producing oil that is not too heavy for transport through the 1,150-mile pipe-line system to the Mediterranean. It is estimated that but a handful of these wells alone could guarantee the annual produce of 4,000,000 tons, which has been laid down as the desirable minimum. Some £10,000,000 have been expended on this pipe-line system—an enormous sum, even for an international organisation—and one which assuredly would not have been forthcoming without reasonable certainty that adequate financial return on the money would ensue.

Diesel-Electric Locomotives.

The English Electric Company have secured an important contract from the London Midland and Scottish Railway for 10 Diesel-electric shunting locomotives, each of 350 h.p. This order is the result of successful tests carried out during the past seven months with a demonstration engine of the same type, facilities for whose trial on an extended scale were given by the L.M.S. This type of locomotive, which weighs 50 tons, is the first Diesel-electric shunting locomotive to be built entirely to British patents.

MARKET PRICES

ALUMINIUM.

98/99% Purity	£100	0	0

ANTIMONY.

English	£74	0	0
Chinese	67	10	0
Crude		—	

BRASS.

Solid Drawn Tubes	lb.	8¾d.
Brazed Tubes	„	10¾d.
Rods Drawn	„	8d.
Wire		7d.
*Extruded Brass Bars	„	3¾d.

COPPER.

Standard Cash	£28	10	0
Electrolytic	31	10	0
Best Selected	30	10	0
Tough	30	0	0
Sheets	58	0	0
Wire Bars	32	0	0
Ingot Bars	32	0	0
Solid Drawn Tubes	lb.	9¼d.	
Brazed Tubes	„	9¼d.	

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	3	3
‡Ferro Tungsten	„	0	3	0
Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
NOMINAL: 2–4% Carbon, scale 11/- per unit	ton	29	15	0
NOMINAL: 4–6% Carbon, scale 7/- per unit	„	23	0	0
NOMINAL: 6–8% Carbon, scale 7/- per unit	„	21	12	0
NOMINAL: 8–10% Carbon, scale 7/- per unit	„	21	12	6
§Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steelwork. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 11/0 per unit	„	34	0	0
Guar. max. 1% Carbon, scale 12/6 per unit	„	38	15	0
§Guar. max. 0·7% Carbon, scale 15/- per unit	„	42	0	0
‡Manganese Metal 97-98% Mn.	lb.	0	1	2
‡Metallic Chromium	„	0	2	5
§ Ferro-Vanadium 25–50%	„	0	12	8
§ Spiegel, 18–20%	ton	7	10	0
Ferro Silicon— Basis 10%, scale 3/- per unit	ton	6	5	0
20/30% basis 25%, scale 3/6 per unit	„	8	17	6
45/50% basis 45%, scale 5/- per unit	„	13	0	0
70/80% basis 75%, scale 7/- per unit	„	18	7	6
90/95% basis 90%, scale 10/- per unit	„	28	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	„	14	0	0
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	4½
Ferro Phosphorus, 20–25%	ton	14	16	0
§ Ferro-Molybdenum, Molyte	lb.	0	4	6
§ Calcium Molybdate	„	0	4	2

FUELS.

Foundry Coke—				
S. Wales	—	1	5	0
Scotland	—	1	8	0
Durham	1 0 0 to	1	5	0
Furnace Coke—				
Scotland	—	1	5	0
S. Wales	—	1	0	0
Durham	—	0	17	6

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£52	0	0
*Commercial Ingots	39	0	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards	lb.	0	0 9
*Cored Bars	„	0	0 11

LEAD.

Soft Foreign	£10	5	0
English	12	10	0

MANUFACTURED IRON.

Scotland—			
Crown Bars, Best	£10	5	0
N.E. Coast—			
Rivets	10	10	0
Best Bars	10	2	6
Common Bars	9	5	0
Lancashire—			
Crown Bars	9	12	6
Hoops £10 10 0 to	12	0	0
Midlands—			
Crown Bars	9	12	6
Marked Bars	12	0	0
Unmarked Bars from	7	5	0
Nut and Bolt Bars £7 10 0 to	8	0	0
Gas Strip	10	12	6
S. Yorks—			
Best Bars	10	15	0
Hoops £10 10 0 to	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards—Solid	lb.	9d.
*Cored Bars	„	11d.
†Strip	„	10d.
†Sheet to 10 W.G.	„	10d.
†Wire	„	11d.
†Rods	„	10d.
†Tubes	„	1/1
†Castings	„	10½d.

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	11	0
Foundry No. 1	3	12	6
„ No. 3	3	10	0
N.E. Coast—			
Hematite No. 1	3	8	0
Foundry No. 1	3	10	0
„ No. 3	3	7	6
„ No. 4	3	6	6
Silicon Iron	3	10	0
Forge	3	6	6
Midlands—			
N. Staffs Forge No. 4	3	7	0
„ Foundry No. 3	3	11	0
Northants—			
Foundry No. 1	3	10	6
Forge No. 4	3	2	6
Foundry No. 3	3	7	6
Derbyshire Forge	3	6	0
„ Foundry No. 1	3	14	0
„ Foundry No. 3	3	11	0
West Coast Hematite	3	7	0
East „ „	3	8	0

SWEDISH CHARCOAL IRON AND STEEL.

Kr. per English ton @ 19·40 to £1 approximately.

Pig Iron Kr. 103
Billets Kr. 240-290 £13 10 0–£16 0 0
Wire Rods Kr. 280-320 £15 15 0–£17 12 6
Rolled Bars (dead soft) Kr. 200-220 £10 12 6–£11 11 0
Rolled Charcoal Iron Bars Kr. 290 16 0 0
All per English ton. f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£24	0	0
„ Braziery	19	0	0
„ Wire		—	
Brass	16	10	0
Gun Metal	22	0	0
Zinc	8	10	0
Aluminium Cuttings	66	0	0
Lead	9	10	0
Heavy Steel—			
S. Wales	2	15	6
Scotland	2	10	0
Cleveland	2	12	0
Cast Iron—			
Midlands	2	7	6
S. Wales	2	11	0
Cleveland	2	12	0
Steel Turnings—			
Cleveland	1	15	0
Midlands	1	14	0
Cast Iron Borings—			
Cleveland	1	5	0
Scotland	1	17	6

SPELTER.

G.O.B. Official		—	
Hard	£10	15	0
English	13	0	0
India	12	5	0
Re-melted	13	5	0

STEEL.

Ship, Bridge, and Tank Plates Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland	8	10	0
„ „ (Marine) „		—	
„ „ (Land), N.E. Coast	8	10	0
„ „ (Marine) „	8	17	6
Angles, Scotland	8	7	6
„ North-East Coast	8	7	6
„ Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	10	0
Light Rails £8 10 0 to	8	15	0
Sheffield—			
Siemens Acid Billets	9	2	6
Hard Basic £6 17 6 to	7	2	6
Medium Basic £6 12 6 and	7	0	0
Soft Basic	5	10	0
Hoops £9 10 0 to	9	15	0
Manchester Hoops £9 0 0 to	10	0	0
Scotland, Sheets 24 B.G.	10	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 14% Tungsten	lb.	2/-
Finished Bars 18% Tungsten	„	2/9
Extras		
Round and Squares, ¼ in. to ½ in.	„	3d.
Under ½ in. to 3/16 in.	„	1/-
Round and Squares 3 in.	„	4d.
Flats under 1 in. × ¾ in.	„	3d.
„ „ ½ in. × ¼ in.	„	1/-

TIN.

Standard Cash	£233	0	0
English	232	17	6
Australian		—	
Eastern	232	0	0

Tin Plates I.C. 20 × 14 box 18/2

ZINC.

English Sheets	£23	10	0
Rods	26	10	0
Battery Plates		—	
Boiler Plates		—	

* McKechnie Brothers, Ltd. † C. Clifford & Son, Ltd. ‡ Murex Limited.

Subject to Market fluctuations. Buyers are advised to send inquiries for current prices.

§ Prices ex warehouse.